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Forthcoming Events.

SEPTEMBER 4-22.
Fifth German Foundry Exhibition at Düsseldorf.

SEPTEMBER 9-12.
Institute of Metals:—Annual Autumn Meeting in Düsseldorf.

Coal-Dust and Chaos.

There has never appeared in any of the 678 issues of THE FOUNDRY TRADE JOURNAL a more interesting and important discussion than that appearing on pages 139 to 142 of the current edition.

The standardisation of and familiarisation with the nomenclature of the subject is the first essential. Because of the abundance, variety and excellence of European moulding sands, it has appeared in the past to be better business to change a source of supply rather than to ascertain by research methods reliable mathematically data as to the properties of this fundamental raw material. These remarks apply with equal force to the coal-dust used. Rapid progress will not be achieved until "coarse," "medium," "superfine," "fat," "strong," and a host of similar expressions have been replaced by figures as well understood and appreciated as 1.5 per silicon when used in connection with cast iron.

The discussion revealed some very interesting and pertinent viewpoints. It must be confessed that Mr. J. M. Primrose's condemnation of the use of coal-dust was logical, the sole factor he apparently did not deem worthy of consideration was its effect on the heat-conductivity of the sand wall by the generation of gases, a factor which obviously reacts on the cooling of the casting. We think that sufficient evidence is now available to conclude that no combustion of coal, coke, tarry matter and often the highly inflammable gases takes place inside a mould cavity, unless this cavity is of exceptionally large dimensions. Tar is a very easily ignited material, yet Mr. Skerl states, without any reservation, that 50 per cent. of the black material in black sand is composed of this substance.

We cannot imagine that generations of foundrymen, spread all over the world, would continue to incorporate coal-dust in sand mixtures for light castings for the mere pleasure of making the sand dirty. There must be some very good and profound reasons for so doing. As the matter stands at present, there appears to be a wonderful scope for further profitable research on the lines so commendably originated by Mr. Hird.

Iron, Steel and Electricity.

It is a fairly well-known fact that the heavy industries in this country are by no means as fully electrified as those of our industrial competitors, or, to state the case a little differently, by no means as fully as may be considered possible or desirable. One important reason—possibly the principal reason—for this lies in the shortage of capital over the past ten years or so, and although electrification would seem to be an obvious development in line with the amalgamations and rationalisation processes that are going on everywhere at present, it will of necessity have to follow at some considerable distance. Of course, there is always in this country some little resistance to any form of change, and there is no doubt that as we are able to get the most out of existing plant we are able to put up the most convincing case possible against anything that is suggested as improvement. But the installation of electric power undoubtedly assists mechanisation, and a mechanised industry is undoubtedly more responsive to sudden demands for increased output, while it does reduce the sheer physical labour which is apt to make some kinds of foundry work rather unpopular.

The iron and steel industry, by virtue of the position created by the relative stagnation of the past few years, is likely to need equipment on a large scale if the indications of present improvement are followed up by working out the fullest possibilities of the new combines where economical production is concerned. The installation of such equipment will make the industry a great user of power, and hence the electrical manufacturers, the iron and steel industry, and the power supply industry might with advantage and mutual profit co-operate in the direction desired. The Central Electricity Board is, of course, directly concerned, for ultimately the industry may be expected to consume 10 per cent. of all the power generated in the country. The actual figures for power consumption show that in America and Germany 75 per cent. of the power used in the industry is used for driving electric motors, while the corresponding percentage in Great Britain is only 41 per cent. The possibilities of electrification in industry are considerable, and have hardly received the attention that is their due.

A French Interpretation of the Shear-Tensile Ratio.

Mr. F. Girardet, a prominent foundry owner of St. Die, in the Vosges Department, has outlined, as a user of the shear test, his views on Mr. W. Jolley's researches published in our issues of April 4 and 11. Mr. Girardet writes that in his interesting and conscientious Paper Mr. Jolley proposes to re-establish the tensile test, a test which has been "damned" and should resume its exclusive position by the suppression of the shear test. This latter, Mr. Jolley states, cannot be trusted, because the ratio shear strength to tensile strength, as found by various authors, varies considerably.

Now the shear test has been highly praised principally by French engineers and experts, and already it has gained important successes. The author has adopted and used it since 1925 under the simplest of conditions,* and it has always given satisfaction for the modest requirements for which it was intended. That prompted him to present the following reflections:—

The tensile test requires much time and care, and rigorous conditions which are not always achieved in industrial tests. Further, it evaluates only the test-bar and not the casting. Lack of space presents enlargement on these points, which are well understood.

The maximum stress obtained by the tensile test is not as directly applicable as that of the shear test. The shear test is much more rapid and economical, thereby allowing a wide application, and, consequently, will have a marked influence upon the progress of founding by the control of material.

The variation of the ratio tensile to shear strength is quite insufficient to warrant the rejection of the shear test. This ratio is affected equally by variations of the tensile strength coefficient. Can one postulate that perfect precision for the tensile test has been attained? Surely it is the contrary which is the most generally admitted and demonstrated.

On the other hand, the criticism levelled against the method of sampling by trepanning is justified. This method, which eliminates machining and permits the sampling of the castings themselves, has these two great advantages in its favour. But it must be distinctly recognised that the dimensions of the test-pieces are variable, and that the test-pieces are never round. The author has shown elsewhere how he minimises that particular cause of error. In spite of this, the further improvement of the trepanning tools is still of paramount importance. The distinct improvement created by M. Guillery is definitely commendable.

Mr. Jolley points out that the results of the shear test vary with the size of the test-piece. This is also the case with the tensile and transverse tests. It is an inevitable result of the structure of cast iron, which diminishes, however, with the improvement of the structure.

The curve which Mr. Jolley gives of the variation of shear-tensile ratio shows us that for a small Frémont test-piece of 2.2 in. this ratio varies from 1.60 to 1.31 when the strength of the iron increases from 17 to 28 tons. In other words, the ratio decreases by 17.5 per cent. when the strength of the iron increases by 64.7 per cent.

The conclusion which is inferred is that for irons of much the same strength, the ratio does not vary appreciably. This, in particular, is the case with samples taken from various points of the same casting. And one is able, moreover, to utilise the curve for making the correction.

Finally, when the iron is of good quality, the test-piece of small section represents quite sufficiently the quality of the metal of the casting; and the differences that one finds eventually between test-pieces originating from several points of the same casting give information as to the homogeneity of this casting and the average qualities of the metal.

It is necessary, however, for these test-pieces to be taken by the same drill, the drilling speed being as nearly the same as possible, and not presenting amongst themselves too marked differences in size of section.

* F. Girardet, "The Scientific Control of Material in the Medium-Sized and Small Iron Foundries." Bulletin de l'Association Technique de Fonderie, 1927, pp. 42-53.

Visit to German Foundry Exhibition.

As indicated in a recent issue, a party, organised by the British Cast Iron Research Association on the lines that proved so successful in 1925, will visit the Foundry Exhibition at Düsseldorf in September. All grades of members are eligible to join the party, including all those employed by member firms. Details of the programme and arrangements have been circulated to all members in Great Britain, and if there are any who have not received particulars or who would like them repeated, they are asked to communicate with the Director.

The party will leave London (Liverpool Street Station) by Harwich-Hook of Holland at 8.15 p.m. on Wednesday, September 11, reaching Düsseldorf before noon the following day. It will return on the evening of Sunday, September 15, arriving in London about 8.30 a.m. on Monday morning.

Either one or two days, as desired (Saturday and/or Sunday), may be spent at the Exhibition. The principal features of this have been given in a previous issue. The commercial exhibits will be grouped around the Educational Exhibit, and all will conform to the guiding principle of the Exhibition, "Economy in Foundry Practice." Although this is described as an Educational Exhibit, it does not concern itself with methods of foundry education. It is a non-commercial exhibit of foundry developments for the information and enlightenment of visitors, and would be described on this side as a technical exhibit.

It is hoped to arrange several foundry visits for the rest of the time, including one of the new type pulverised-fuel furnaces for cast-iron melting. In addition, visits are projected to the Vereinigte Stahlwerke, Gelsenkirchen, and the Gasmotorenfabrik Deutz.

As our readers know, the Autumn Meeting of the Institute of Metals is being held in Düsseldorf immediately before the C.I.R.A. visit, and over a dozen members of the Association who have registered for the former visit have intimated their intention of staying on for the second. Anyone who is interested in the proposed visit is invited to communicate with the Director of the C.I.R.A., as the addition of a few more names will make it possible to take advantage of the lowest terms quoted for the party by Thos. Cook & Sons. The cost will be below £10 per head, including second-class rail and first-class steamer accommodation, meals en route both ways, hotel accommodation, service, and breakfast (but not lunch and dinner) on days in Düsseldorf, gratuities, etc. It does not include travelling expenses in connection with visits.

Foundry Specifications Issued.—Copies of the following specifications, interesting for certain types of foundries, can be had on application to H.M. Stationery Office, Adastral House, Kingsway, London, W.C.2:—Specification for "Baths, slipper, cast iron, enamelled," Interdepartmental Specification No. 3 of 1929 (price 1½d. post free). In this six types of baths are detailed. Specification for "Sash Chains and Pulleys," Interdepartmental Specification No. 4 of 1929 (price 1½d. post free). Herein 1¼-, 2- and 2½-in. pulleys and the chains and fittings for use with them are outlined. Specification for "Aluminium-Copper, Silicon, Light Alloy Castings," Air Ministry Aircraft Specification No. D.T.D. 84 (price 2½d. post free). This skeleton specification is one of those issued either to meet a limited demand not covered by any existing B.E.S.A. specification or to serve as a basis for inspection of materials whose properties and uses are not sufficiently developed as to warrant submission to the B.E.S.A. for standardisation.

Random Shots.

The use of pulverised fuel is arousing increasing interest at the present time, and attention is consequently being drawn to the necessity for carefully avoiding the risks that may arise from the highly inflammable character of finely-divided coal. That this risk is a very real one will be endorsed by those who have had practical experience of the materials in question, and it was demonstrated beyond question by a recent accident in South Wales, when one man was killed and several were injured by a coal-dust explosion arising from the proximity of an acetylene flare. We might do worse in this matter than study the precautionary methods of our friends in the coal-mining industry. Such difficulties are due almost entirely to ignorance, and with ordinary care nothing of the kind need be experienced. That very combustibility which is so signal an advantage in use need not, therefore, be a bar to the widespread adoption of fuel of this type.

* * *

In connection with my recent remarks on international language complications, I was recently besought by a distinguished friend to call attention to a notorious abuse. He prefaced his appeal by a most pathetic story, telling me that he had been chastised, I forget how many dozen times, in the days of his youth for translating the French expression, "assister à," by "to assist at," when it should be, "to be present at." Nowadays, he pointed out, the phrase so obnoxious to the preceptors of his youth is to be found in all sorts of company—accounts of fashionable weddings, of business functions, and so on. Now, were my friend a vain man, he might lay claim to prophetic powers, and make much of the stripes that came his way in so good a cause. But, alas, he is modest, and he was well taught (or well chastised!), and he asks me to point out that in English "to assist" means "to help," and that to be present on a given occasion is very far from meaning to help. Wherefore, "assister à" must be rendered "to be present at."

* * *

And now I will tell you a little story, which shall be positively my last word on the language question—a question, I assure you, that was never intended to claim so much space. Indignant lady in the stalls (unable to see through the large person in front of her): "I understand now why these seats are called 'futiles'!"

* * *

And this story is a true one. An equipment expert of our acquaintance (and possibly of yours, too) was recently extolling a new foundry development to a prospective customer. The latter, although very much impressed, had a few lingering doubts. "But," he asked, "where—er—do you come in?" In deprecating tones, the expert replied: "Well, I must live." To which the customer replied: "But why?"

* * *

If the said customer had not been a foundryman, and therefore exempt from so highbrow a suggestion, he might have been accused of cribbing from the famous French philosopher, Voltaire. An egregious person once protested that he must live, to which Voltaire replied adroitly: "I don't see that it is necessary."

Marksman.

X-ray Examination of Aluminium Castings.—Mr. R. S. Archer, metallurgist for the Aluminium Company of America, in charge of the X-ray Department, is to present a Paper to the delegates to the first National Metal Congress, to be held in Cleveland, September 9 to 13, on radiography. The X-ray according to him is constantly assuming a more important place in metals, and now is capable of piercing about two inches of steel. But aluminium of lighter weight can be penetrated to a depth of ten inches in the search of flaws.

Crystalline Grains in Castings.

By Ing. Dr. A. Glazunov (Professor at the Pribram School of Mines, Czecho-Slovakia).

(*Continued from page* 120.)

Table I details the lowest temperatures at which re-crystallisation can still take place (that is, the fusing of various grains, divided from one another by a layer of amorphous cement, or maybe a layer of impurities). This temperature may be a few hundred, and even a thousand degrees below the melting point. The dependence of the speed of grain growth on the temperature is shown in Fig. 19. In temperatures approximating to the melting point, the size of the grains (that is, the fusion of various grains) has increased several times after thirty minutes' treatment.

As to crystallisation taking place in thin layers, or on the surface of the casting, there

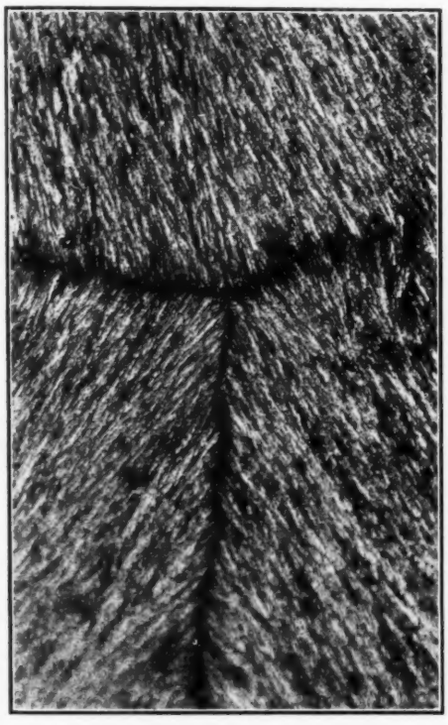

Fig. 18.—Microphotograph of Three Polycrystalline Grains. (Institute of Theoretical Metallurgy, Pribram School of Mines.)

is here no longer any protection from the cooling influence of the surrounding space, as the crystallisation equilibrium $F_{liq} \rightleftharpoons F_{cr}$ takes place circularly, so that the already formed crystals, contained inside the circle, are of a much lower temperature than is the crystallising part. Owing to the lowered temperature, the re-crystallisation process (rendering homogeneous) does not take such an easy course as it does inside a mass during the crystallisation.

Depending upon (1) the absolute temperature at which re-crystallisation takes place, (2) on the capacity of the substance to change at this temperature the orientation of its crystalline units, (3) on the degree of decrease of temperature and (4) from the rapidity with which, under these conditions, the process of rendering the crystals homogeneous takes place, this is total or partial (decrease of the number of rays branches owing to their fusion), or finally none.

The crystallisation process itself, actuating in the thin layers, or on the surface, would take the following course:—(1) From the formed nuclei there begin to grow in different directions star-like crystals with the same rapidity in all directions; (2) depending upon the crystallographic character of the crystal and its definite angles in reference to its axis there are deposited crystalline units. The crystal will also grow in a vertical direction, in reference to its natural radial direction; (3) the rapidity of this process can also be different from the rapidity of the basic axis. KG can be different for every crystallographic axis; (4) this growth will find a mutual obstacle in the growth of the adjacent crystal; (5) if this rapidity resembles (according to the coefficient value) to the speed of the growth of

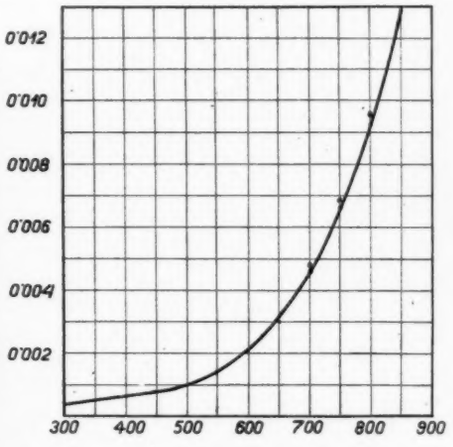

Fig. 19.—Relationship of Grain Growth to Temperature.

the crystal according to the radial axis, there is obtained a typical, circular, growth; (6) if this speed were much smaller than the speed of the radial growth, one would obtain an acicular structure. Such a structure could be used to explain the formation of sulphur needles from liquid, as previously cited; (7) if the capacity for the rendering homogeneous of the substance, under these conditions, is considerable, there is obtained a partial, or even an absolute, elimination of one sort of crystal by the others—one is obtaining a star-shaped, cruciform, or even a

Table I.—*Approximate Lowest Recrystallisation Temperature (Z. Jeffries and R. S. Archer: "The Science of Metals").*

Metal.	Melting point.	Approximate lowest re-crystallisation temperature.
Iron	1,528	450
Nickel	1,452	600
Gold	1,064	200
Silver	961	200
Copper	1,084	200
Aluminium	658	150
Platinum	1,753	450
Magnesium	650	150
Tantalum approx.	2,950	1,000
Tungsten approx.	3,350	1,200
Molybdenum	2,620	900
Zinc	419	Room temperature.
Cadmium	321	Room temperature.
Lead	327	Less than room temperature.
Tin	232	Less than room temperature.

pseudodendritic form; and (8) if this capacity of the substance is low under these conditions, one obtains a typical star-like structure.

This scheme would explain the origin of various types of surface grains. An example of a cruciform structure is shown in Fig. 20. All possible types of crystalline grains of pure substance, as well as their successive transition from one type into the other is represented by the scheme (Table II). A structure, in which, in pure substances, one can be distinguished within the grains a dendritic structure, has been termed by the author "pseudodendritic," in contradistinction to the true dendritic structure (formation of a dendritic skeleton in the course of primary crystallisation), existing in crystallisation from solutions.

The process of the formation of the structure in question always takes its course to the right, as indicated in Table II, and that being so, initially there is formed a star-like structure, which then, independently from the outside factors, either persists, or changes, and that, at such a distance to the right, as is admitted by the crystallisation conditions. Its homo-

Fig. 20.—A Cross-shaped Structure. From the Book, "Das Technische Eisen," by P. Oberhoffer.

geneity may, under suitable conditions, effect itself so rapidly, that already during the formation of star-like crystals, initially there occurs an absorption of one crystal by the other, so that still early on in the crystallisation process one may obtain a unicrystalline composition of the grain (pseudodendrite in cross-section).

If the crystallisation process takes place from a solution, or, similarly, from a molten alloy, one

Fig. 21.—Growth of Binary Alloy.

Fig. 22.—Growth of Ternary Eutectic.

will always have the possibilities shown in Table III. The type of Group III is not dealt with in this Paper, for in a chemically stable combination there will not be any difference according to the crystallisation process of the types of Groups I or II, and in the case of the formation of decomposing chemical combinations—that is, when these are formed in the course of the crystallisation process by a reaction between the precipitated crystals and the liquid—one will obtain, not a primary formation of crystalline grains, but a complicated secondary process, which is extraneous. Equally the type of Group II, 2, B (*a*) is not discussed, because it is also a secondary process.

The types of the Groups II, 2, A, and II, 1, are not different from one another in the sense of the crystallisation process. Consequently the types of the Groups I, 1; I, 2; II, 1 and II, 2, B, b, alone remain.

Group I, 1.—The most important case is the type of Group I, 1, that is, the crystallisation of pure substance from solution. As in this case, also in all of the other cases, in the crystallisation of alloys, except the above-mentioned factors determinating the crystalline process, an important part is played by the concentration of the solution, the change of its concentration during the process of crystallisation and the relation between the rapidity of diffusion in the concentration and the linear crystallisation speed; in the case of the crystallisation of solid solution, the diffusion in the already precipitated crystals also plays an important part.

In case I, 1, when the concentration of solution (under the existing thermal conditions) has attained saturation, the crystals of the pure substance begin to precipitate according to the liquidus curve in definite intervals of temperature, when the temperature will decrease and at a constant temperature in the case of the crystallisation from the solution, when the solvent will gradually disappear.

If the crystallisation takes a very slow course, that, is, when the time between the beginning of crystallisation and the final eutectic solidification of the solution is very considerable (the process evidences itself only with a very low supercooling—low KG and low KZ), and chiefly because the absolute value for KG will be low, one obtains large, well-developed, idiomorphic crystals.

Table II.

Exterior grains.			Interior grains.	
	With secondary crystallisation (with homogeneisation).			
Without secondary crystallisation (without homogeneisation).	Partial homogeneisation	Complete homogeneisation.		
		Original crystallisation centre still to be observed.	Original nucleus disappeared.	
Star-like grain structure.	Star-shaped grain structure.	Cruciform grain structure.	Pseudodendritic grain structure.	Homogeneous grain.
→	→	→	→	

Table III.

In crystallisation from solution the following cases may occur :—

- I.—Crystallisation of pure substance
  - 1.—The composition of the alloy is indeterminate, except the eutectic composition
  - 2.—The composition of the alloy corresponds to the eutectic composition
- III.—Crystallisation of chemical combination of the dissolved substance from the solvent
- II.—Crystallisation of solid solution
  - 1.—Discontinuous solid solution
  - 2.—Restricted solubility in crystalline state
    - A.—Composition of the alloy lying within the limits of solid solutions
    - B.—Composition of the alloy lying in the intervals between the solid solutions
      - (A).—IV. Roozeboom type
      - (B).—V. Roozeboom type

Process of the Production of Idiomorphic Crystals.

Equally as in the crystallisation process of the pure substances already outlined, nuclei are formed very sparsely. One may suppose, provided the hypothesis propounded is accepted, that initially, from the nuclei, crystals begin to grow in all directions, yet before they reach any considerable size, equalisation is already taking place and the crystal assumes its innate crystallographic form. Moreover, if KG is low, there constantly will be deposited on this crystal new and fresh layers of crystal; from the saturated solution surrounding it one thus obtains an idiomorphic crystal. If KG is higher than the concentration of the solution, the solution in the immediate vicinity of the surface will be poorer by the dissolved substance; the regularity of the growth will be interfered with and the formation of dendrites started. The crystallising substance will require more material for its growth in other parts of the solution if it is not in the immediate vicinity of the surface. In this manner one obtains a true dendritic structure.

Table IV.

Crystallites may be

- A.—Chemically homogeneous
  - I.—Physically homogeneous
    - 1.—Idiomorphic crystal
    - 2—Allotrimorphic crystal ←—(homogeneisation)
      - (A).—Of ray-shaped origin
      - (B).—Of dendritic origin
  - II.—Physically hetrogeneous
- B.—Chemically heterogeneous
  - I.—Composite of different variations of a phase
  - II.—Composite of different phases

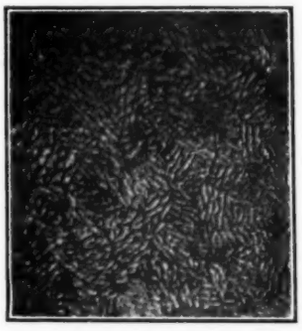

Fig. 23.—Eutectic Structure—Radiatiform Structure. From the Book, "Lehrbuch der Metallographie," by J. Tammann.

The influence of the impoverishment of the solution in the immediate vicinity of the crystallisation surface—owing to a high value for KG—on the precipitating metal may be easily observed in the process of the electrolytic precipitation of metals on the cathode, which follows the same principles as the crystallisation from a molten bath—that is, according to KG and KZ. On the edges of the cathode (supposing it is being worked with a maximum density of current, in which a good cathode deposition may still be obtained there), whereby the density of the current is still higher, branches of a dendritic character begin to form, the precipitating metal requiring more material for the construction of its crystal.

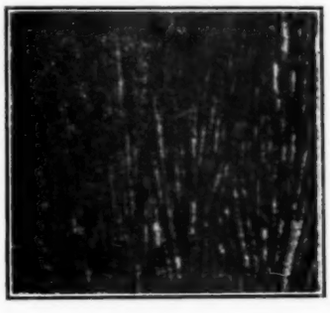

Fig. 24.—Eutectic Structure—Fine-grained Structure. From the Book, "Lehrbuch der Metallographie," by J. Tammann.

If the crystallisation process reaches finality, the precipitation of the eutectic begins at the eutectic temperature. This surrounds the previously-precipitated crystals, whether dendrites or idiomorphic. Naturally this will occur only if the alloy chosen is of a composition approximating to the eutectic composition, that is if the quantity of eutectic is greater than that of the precipitating primary crystals. On the contrary, *i.e.*, if the quantity of primary crystals is larger than the eutectic, the precipitated crystals will constitute an obstacle to each other

as to growth. In the crystallisation of pure substances one obtains a polyhedral structure, whereby the dendritic structure of the polyhedrons are almost always clear. The remaining quantity of liquid solidifies eutectically between the individual polyhedrons.

Formation of Nuclei from Eutectic Alloys.

The type of Group I, 2, represents an alloy of eutectic composition. For clarity it is proposed to treat the most usual case, that is, an alloy composed of an indefinite quantity of constituents, so that this may correspond to whatever eutectics exist. It is immaterial whether this eutectic is mono-, bi-, tri- or " n "-variant.

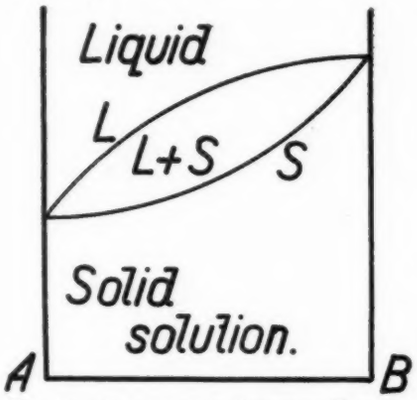

Fig. 25.—Roozeboom's Diagram, Type I.

It is sufficient to have an eutectic, *i.e.*, a composition, in which the liquid will be saturated at the same time with some, or at least two, components. In this case, the precipitation of the smallest particle of one constituent will immediately be followed by the precipitation of the second component. This supersaturation occurs in the *immediate* vicinity of the precipitated particle, so that the precipitation of these other constituents of the eutectic will take place in

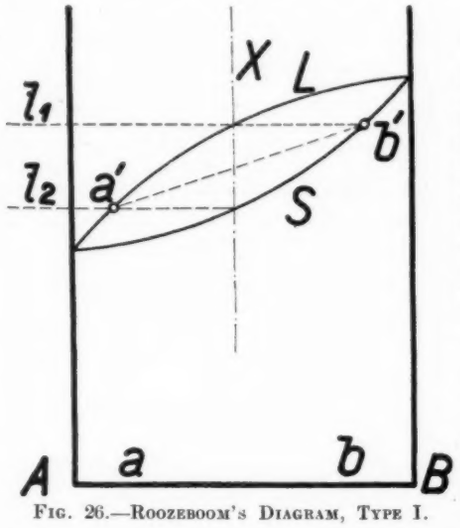

Fig. 26.—Roozeboom's Diagram, Type I.

the immediate vicinity of the precipitated crystal, that is, near the same nucleus. The number of the crystallisation centres will depend on the supercooling. The linear crystallisation speed will assume another value for each of the constituents of the eutectic.

The process of the crystallisation of the eutectic itself will act in the following manner: For every time-unit, a definite number of nuclei will form, and from these eutectics begin to grow in all directions (spheroidally). These eutectics are constituted of as many constituents as there are in the eutectic. Naturally the crystals in this case growing from one nucleus will have a different chemical composition, so that the adjacent crystals or branches will be of various phases.

In the simplest case, that is, in the case of the binary eutectic, a growth is formed according to the scheme represented in Fig. 21 (the white branches refer to component A, the black ones to component B). In a ternary eutectic (Fig. 22) there are branches of the white component A, of the black component B, and of the grey component C. As a result a star-like structure with a spheroidal growth of the eutectic grains is obtained, constituted not only of crystals orientated in a different way, but also of varying chemical composition. In this case, the fusion of the individual branches is impossible without an absolute overcrystallisation, that is without the change of the size of the original grains, and crystals of similar chemical composition will be separated from each other through other crystals.

Sometimes, instead of the typical star-like structure, the fine-grained structure of the eutectic is obtained, yet, as is shown in Fig. 23 and Fig. 24, the difference in the structure is dependent on the way in which the surface of the specimen intersects the eutectic grain. Considering that the eutectic grains can be of very considerable dimensions (for instance, Hargreaves obtained with lead-tin eutectic grains measuring one inch), it is not surprising that the intersection of the individual branches of a crystal give a microstructure similar to small polyhedrons, as shown in Fig. 23.

If a solid solution is formed, that is of the type of the Group II, 1, the process will take its course in a similar way to the crystallisation of pure substance, except that it is a little more complicated. In this case, the formation of one or another sort of crystals will be dependent not only on the factors already mentioned above, but also on the rapidity of diffusion in the liquid, as well as in the crystalline phase, and also on the reciprocal distance at constant temperatures (in the crystallisation interval) of the " solidus " and " liquidus " curves.

Binary Systems.

In the higher systems there will be the same as the binary, except that instead of the " liquidus " and " solidus " curves there will be either surfaces of double curvature or spaces of higher dimensions. In the binary system the process of crystallisation, assuming definite miscibility in the liquid state, as well as in the crystalline one, takes its course according to Fig. 25 (referring only to Type I of Roozeboom, because II and III do not materially differ from it). During the crystallisation process of the alloy of some composition—for instance, of the composition X in Fig. 26.—its temperature will change from t_1 up to t_2, the composition of the liquid phase from X to a (according to curve L), the composition of the crystalline phase from b to X (according to curve S), but the composition of the precipitating crystals every moment will change from b to a, according to some curve b-a, whereby the composition of the first precipitated crystal, in the immediate vicinity of the crystallisation centre, or the composition of the nucleus, will correspond to the point b, and the composition of the last precipitated crystal on the periphery of the grain will correspond to the composition of the point a.

It is obvious that the greater the distance of the points lying at the same temperature on the " liquidus " and " solidus " curves, and from the fact that the greater the distance between a and b, the greater is the difference in the composition of the crystallising substance during the crystallisation process, and the greater is the difficulty to obtain homogeneous (also in the chemical sense) crystalline grains.

As shown in Fig. 27 and 28, the difference in chemical composition between first crystalline germ b and its part, finally precipitated (a) is in the first case (Fig. 27) much less than in the second one (Fig. 28). Varying with the rapidity of cooling, the diffusion in the crystalline state and on the reciprocal distance of the points a and b one obtains homogeneous or heterogeneous grains. The shape of the grains (either polyhedral or pseudodendritic, etc.) depends on the conditions of crystallisation, exactly as was the case with the solidification of pure substance.

In the case of solidification of the system according to Type Group II, 2, B, b, crystals will be formed according to the mono- or polyvariant process (that is, taking its course in a thermal interval), from nuclei, from which spheroidal star-like crystals will grow. Thus

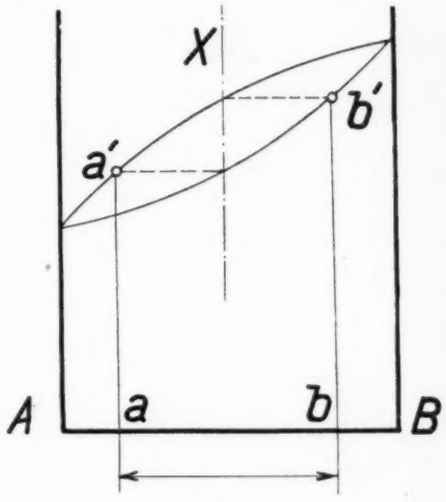

Fig. 27.

one obtains either a formation of an idiomorphic crystal or of polyhedrons in intervals, between which will be a eutectic or a dendritic structure, whereby the individual polyhedrons or dendrites, independently of the composition of the alloy (on its remoteness from the eutectic composition) will have common limits or will be surrounded by a eutectic. The difference rests

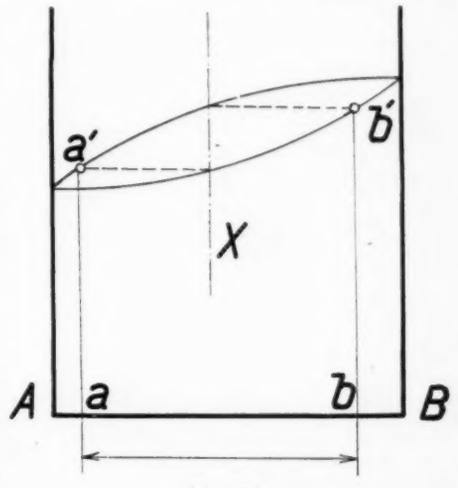

Fig. 28.

only in the fact that the growing grains, spheroidal or dendritic, during their growth of various composition (and one obtains these primary crystals of the same different composition in their various parts) depending on the rapidity of cooling, on the rapidity on the diffusion in crystalline state and on the distance between " solidus " and " liquidus " curves. This process is illustrated in Figs. 29 and 30.

Obviously in the case illustrated in Fig. 29 the chemical equalisation is more difficult than in the case of Fig. 30, primarily due to condi-

tions of cooling. The difference between the chemical composition of the first-precipitated crystal element and the last one (*a-b*) is greater in this case. With this case, that is the diagram in which the "solidus" curve is of concave shape, the crystallisation of the primary austenite in the iron-carbon diagram can be associated. The heterogeneity of dendrite in the crystallisation of iron alloys can thus be explained.

This chemical heterogeneity of the individual parts of dendrite makes their physical homogeneisation difficult, that is it renders difficult the formation of homogeneous polyhedrons, through which there is a reason why, in iron alloys, even if they have been worked, primary dendrites may still be observed. The homogeneisation of grains requires initially in this case a chemical homogeneisation, and only

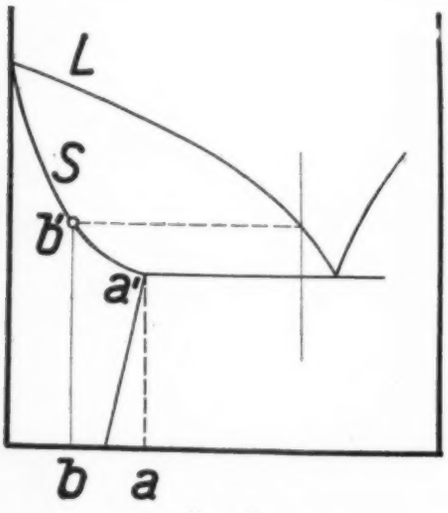

Fig. 29.

afterwards their fusion will be possible, that is, the physical homogeneisation.

Basically, the course of crystallisation remains always the same. There is always formed a nucleus from which crystals grow in various ways, yet always in every direction. Independently of the circumstances whether the system has an absolute crystallisation, a homogeneous or a heterogeneous constitution, there are always obtained grains of various shape (homogeneous or heterogeneous) whereby every grain has been formed from one nucleus.

The author suggests that such a grain, formed from one nucleus, should be called a "crystallite." If this definition is correct, one obtains thereby a clear conception of a "crystallite," and at the same time there will be no objection to Tammann's and Sauveur's conception of a crystallite. All crystallites could be in this case classified according to the following scheme:—

(A) *Chemically homogeneous*, that is constituted of various crystals belonging to one and the same phase, and possessing an equal chemical composition. This case is obtained in the crystallisation of molten pure substances, in the crystallisation of solid solutions, when the diffusion in crystalline state takes its course rapidly, so that the rapidity of cooling is low and that the distance between *a-b* is not too great; equally a chemically-homogeneous crystallite is obtained in the crystallisation of a substance from solution in a composition differing from the eutectic composition. These chemical-homogeneous crystallites may be:—(I) Physically homogeneous, which occurs if the recrystallisation process is rapid during the crystallisation process. Depending upon the fact, whether the pure substance crystallises from its molten bath or from the solution (in the latter case according to whether the composition approximates that of the eutectic or not), one obtains either idiomorphic crystals or allotrimorphic crystals, that is monocrystallic polyhedrons. The latter may arise from dendrites or from branches.

(IIa) The physically-heterogeneous crystallite, that is the polycrystalline crystallite, which constitution one obtains under conditions, in which homogeneisation in the internal part of the crystallite is made impossible by the conditions of the crystallisation process. The structure will be star-like. This structure is chiefly observed on the surface of the casting or in the crystallisation of thin layers.

(B) *Chemically heterogeneous.* This constitution of crystallites is obtained in the crystallisation of solid solutions (under such crystallising conditions which render impossible the equi-

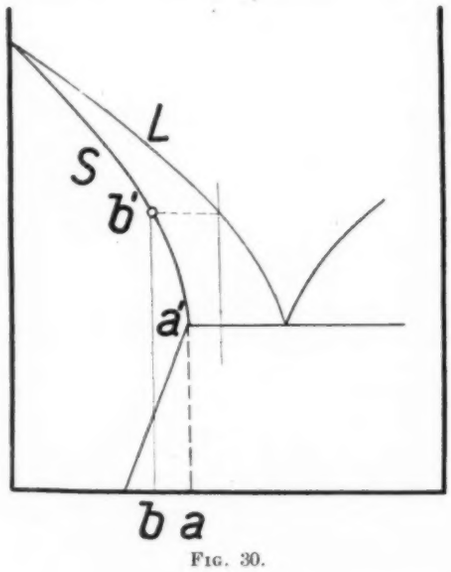

Fig. 30.

librium of the constitution of the precipitated crystals), or in the crystallisation of eutectics. Chemically heterogeneous crystallites may be:—(1) Constituted of crystals belonging to the same phase, with the exception that the internal part of the crystal will be different (varying with the chemical composition) from the surface, whereby there will be from the internal part up to the surface a continuous transition. This case will be obtained in solid solutions.

(III) Constituted of crystals belonging to various phases—a typical case being the solidification of eutectics. The constitution is normally star-like, and from the same nucleus crystals belonging to various phases grow. The boundaries between the individual crystals of various chemical constitution are very sharp.

This classification of crystals is outlined in Table IV.

Summary.

(*a*) Assuming the metal formation of homogeneous polyhedrons (crystallites), such as grains of metal. They are always star-shaped.

(*b*) These can still, during their growth, become homogeneous, and one obtains either an entirely homogeneous crystallite, or entity in which a dendritic structure may be distinguished as a product of primary homogeneisation.

(*c*) Dendrites in pure metals (pseudodendrites) are of secondary origin—the product of homogeneisation of primary "rays."

(*d*) The trend towards homogeneisation of grains (towards the fusion of the individual crystals) is the tendency of every system to increase its entropy, that is to decrease the free energy. Here the tendency is for the decrease of the surface energy by the decrease of the surface.

(*e*) This process only takes place within the boundaries of one crystallite, because in the fusion of various crystallites it is necessary to overcome the resistance of the intercrystalline cement, as well as finally that of the occasional residual impurities.

(*f*) If the crystallisation process takes its course practically in a bi-dimensional space, it is very probable that a polycrystalline (star-like) crystallite will be obtained.

(*g*) Every crystallite, that is every grain, independently of whether it is homogeneous or heterogeneous, grows from one nucleus.

(*h*) In the crystallisation of pure substances from the bath there is either a spheroidal growth or one according to the crystallographic orientation.

(*i*) The dendritic constitution which is sometimes shown on grains of pure substances is not primary, but it is the product of homogeneisation—and may be termed "pseudodendritic."

(*j*) In the case of selective crystallisation of pure substances from solution, the growth of the crystals may be dependent on the conditions of crystallisation, either according to the crystallographic orientation, or spheroidal or finally dendritic.

(*k*) The same may be observed also in solid solutions.

(*l*) In the case of crystallisation of alloy of eutectic composition, chemically-heterogeneous grains and a chemically-heterogeneous crystallite is obtained. In this case no homogeneisation within the boundaries of one crystallite is possible.

Sir W. G. Armstrong, Whitworth & Company, Limited.

This company's business has been reorganised, and in future its engineering and shipbuilding activities will, for reasons of greater efficiency, be conducted as separate units. For this purpose there has been formed two operating companies, and below are given some particulars regarding them.

Sir W. G. Armstrong Whitworth & Company (Engineers), Limited.—This Company has taken over the Scotswood Works at Newcastle-upon-Tyne and the Close Works at Gateshead and will conduct the whole of Armstrongs' locomotive and general engineering businesses, including the manufacture of general foundry products. It as a capital of £1,500,000, the whole of which is owned by Armstrongs, and it will carry out all future contracts relating to those businesses.

Mr. Benjamin Irving, M.I.Mech.E., will continue to act as managing director in charge of these Works, and the Sales Organisation will remain under the direction of Lt.-Col. C. F. Hitchins, D.S.O., M.I.Mech.E., M.I.N.A., the Managing Director in charge of Sales at the London Offices.

Sir W. G. Armstrong Whitworth & Company (Shipbrokers), Limited.—This Company has taken over all the Shipyards, that is to say, the Dobson Shipyard, the Walker Shipyard, and the Tyne Iron Shipyard, all on the River Tyne, and will be responsible for the whole of Armstrongs' Shipbuilding activities. It has a capital of £750,000, the whole of which is owned by Armstrongs, and it will carry out all future shipbuilding contracts.

Mr. James Stewart, O.B.E., M.I.N.A., will continue to act as Managing Director in control of the Shipyards, and the Sales Organisation will be in the hands of Lt.-Col. C. F. Hitchins, D.S.O., M.I.Mech.E., M.I.N.A., as before.

Sir W. G. Armstrong Whitworth & Company, Limited (that is, the Parent Company), will hereafter be called "Armstrong Whitworth Securities Company, Limited," in order to distinguish it from the Engineering Company and the Shipbuilding Company, through which two Companies it will as above described, carry on its manufacturing operations in the future.

The Vocational Training of Foundry Workers, Foremen and Engineers in Belgium.

Presented on Behalf of the Belgian Foundrymen's Association.

(*Continued from page* 123.)

Evening Vocational Courses.

The evening vocational courses constitute one of the divisions of the Labour University, their object being to enable apprentices and workers employed in local industrial concerns to complete their vocational training. The normal duration of the foundry classes is 3 years. To be admitted, students must be at least 14 years of age, have had a complete primary education, and been in the trade for not less than three months.

First Year.—The times devoted every week to the various subjects taught are as follows:—Mathematics and geometry, 2 hours; drawing, 2 hours; vocational technology, 1 hour, and practical work, 4 hours.

Second Year.—Drawing, 2 hours; technology, 2 hours, and practical work, 4 hours.

Third Year.—Technique of foundry work, 2 hours; moulding, 5 hours; practical work, 4 hours, and social education, 1 hour.

Students having obtained their diploma can attend the advanced foundry-courses which will be shortly organised at the Labour University. The theoretical and practical instruction given in the above course is conceived absolutely in the same spirit as that governing the Day-time Vocational School, duly taking into account, on the one hand, the difference in the general education of the students, and, on the other hand, their age and initial practical knowledge.

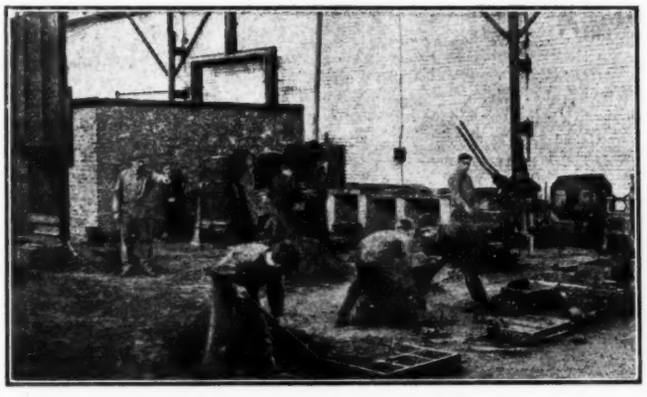

Fig. 11.—Moulding Shop at the Labour University, Charleroi.

Plant.

The foundry run by the Labour University comprises the following plant: A cupola having a 30 cwt. per hour capacity, which can be used for the production of cast iron or steel, as required. This furnace feeds a ½ ton converter.

A second ½ ton per hour cupola is used for the production of medium-sized castings for experimental purposes. This furnace was in fact specially constructed with this end in view, and it makes it possible to carry out research work in connection with semi-steel mixtures, the heating of the hearth, the study of combustion, the analysis of the gases, the study of temperatures in the different zones, etc.; drying stoves and a modern shop for the preparation of sand; a series of pit fires for melting bronze and other alloys; several moulding machines, and a machine for removing sand from castings. Mechanical handling is effected by means of a 5-ton electric overhead crane. Figs. 11, etc., show various views of the Labour University.

Communal Vocational School of Mechanics at Liége.

The Vocational School of Mechanics was established in 1902 upon the initiative of industrialists in the metallurgical district of Liége. The practical Sections at present organised are as follows:—Fitting, erecting and machine shops, forge and pattern-shop.

Want of available space has made it impossible to organise the foundry section, the necessity for which has long been recognised by the Administration of the School. A room about 27 metres long by 15 metres wide has accordingly been set apart for the foundry section in new premises, the construction of which has just been commenced by the City of Liége. These will be ready in 1930.

In view of the impossibility for the time being of establishing a well-organised foundry section in connection with the day-time school, and recognising the urgent necessity of doing something towards the vocational training of competent foundry workers, the mechanics institute in 1915 organised a foundry technology course, which is held every Sunday morning, from 8 to 12 a.m., in the winter months. This course, which takes two years to complete, is open to moulders whose ages rank from 18 to 25, or even to older men in certain cases.

Notwithstanding all the efforts made, this foundry course is not sufficiently well attended. Moulding as a trade has gradually grown in disfavour amongst the younger members of the working classes, who prefer to take up trades which are either more fashionable (such as automobile or electrical engineering) or cleaner (fitting, pattern-making, machine-tool minding). The evil is a real one, but the demonstration foundries which make rational training possible, and have met with such conspicuous success at Charleroi and Verviers, give the City of Liége every hope of a greatly improved attendance in the future.

Foundry School organised by the "Compagnie Générale des Conduites d'Eau" at Liége.

This School, which was founded in 1927, provides for theoretical and practical instruction extending over a period of three years.

I.—Theoretical and Practical Courses.

Classes are held for eight hours every day, either one, one and a-half, or two hours of which time are devoted to theoretical instruction, the remainder being occupied by practical instruction. This is given in two shops, one for moulding and one for pattern-making, according to the special line chosen by the apprentice. But all students must attend every theoretical course, irrespective of the speciality selected.

(*a*) *Theoretical Courses.*—The object and tendency of these courses is to give the apprentice some general training and such instruction as will be sufficient to enable him to qualify as a worker of outstanding ability. Both in the selection of the subjects taught and in the mode of their presentation, great care is exercised to avoid anything which could give the pupil the dangerous illusion that he will become a scientist in a small way. This is indeed a peril that must be eliminated, because apart from pedantry which is so highly undesirable in itself, it would tend to awaken in the student the desire to give up manual work, and have the two-fold disadvantage of frustrating the object of the foundry school—which is to succeed in training good and competent workers—and of turning the apprentice into a sort of *déclassé* for whom the future might have painful disillusionments in store.

The object of the theoretical courses is to develop the pupil's critical capacity, sagacity and intelligent judgment quite as much as—if not more than—to impart the rudiments which are the subject-matter of the courses. The instruction also embraces everything calculated to favour the development of a "professional conscience" in the apprentice. It is thus seen that moral education, intellectual training, and the acquisition of useful knowledge constitute the three main objects pursued by this theoretical tuition.

In the first two years, instruction is given in drawing and geometry, patternmaking, scientific rudiments indispensable in foundry work, French and arithmetic. The third year curriculum, which is not to be organised until October, 1929, will be designed merely to develop the pupil's knowledge of the above subjects.

(*b*) *Practical Courses.* — Practical instruction is given in two separate workshops (pattern-making and moulding), in accordance with the special line chosen by the apprentice. During the first two years, the students are not brought into contact with the men employed at the works. In the third year (regarded as a transitory period during which the pupils are expected to adapt themselves to factory life) they are placed in various departments of the works and put under the charge of foremen, while still remaining under the authority of the school instructor (who must see that each apprentice duly continues his vocational education), and also under the vigilent supervision of the principal of the school, who will thus be able to guard the pupils against any detrimental influence exerted by the older men.

This practical instruction continued over periods which vary according to the circumstances of each pupil individually, and, as directed by the principal of the school, has for its sole aim the quality of the work without any regard to rapidity of execution. When the pupil has attained a sufficient degree of proficiency, he is encouraged to execute the work more rapidly by the payment of a bonus. Rapidity of execution, however, is taken into consideration only if a sufficiently high standard is maintained in the quality of the work.

Remuneration of Apprentices.

This remuneration consists of a basic wage, as fixed by the regulations, in respect of each of the three years. The maximum rates may be exceeded in the case of apprentices showing exceptional ability. To the basic wage are added monthly premiums, calculated in proportion to the number of marks awarded in any one month at the theoretical and practical courses. These premiums may be as high as 30 per cent. of the

basic wage. In addition, a fixed premium is payable (1) upon the signing of the apprenticeship agreement; (2) at the end of each year of school attendance; and (3) two years after the completion of the apprenticeship, if the worker is still employed at the works. Finally, prizes are also awarded at the end of each year of school attendance.

Apprenticeship Agreement.—This agreement must be signed by the apprentice and his parents at the end of the first period of three months. The agreement is worded as follows:—

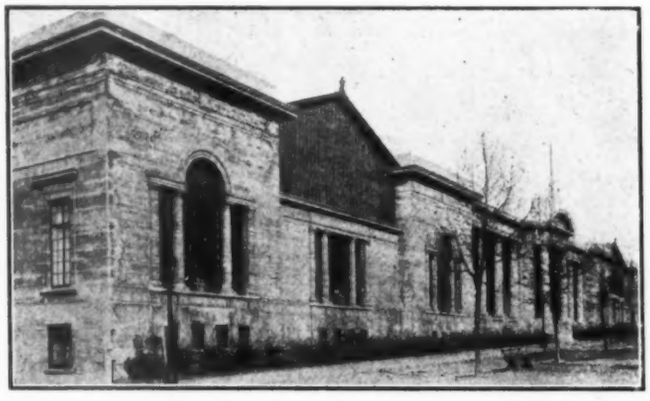

Fig. 12.—Exterior View of the Labour University, Charleroi.

Apprenticeship Agreement.

Between the undersigned:—

(1) The "Compagnie Générale des Conduites d'Eau," represented by Mr. ——, Principal of the aforesaid Company's Foundry School, of Quai de Condroz, Vennes, Liége, of the first part; and

(2) Mr. ——, acting in his own name and in the capacity of father (or guardian), of the second part.

It Has Been Agreed as Follows:—

Art. 1.—The contracting party of the second part gives on behalf of his son (or ward), , an undertaking to the effect that his son (or ward) shall undergo training as apprentice for a period of three years as from at the aforesaid Company's School.

Art. 2.—He also undertakes to cause his son (or ward) to comply with the clauses of this Agreement and to perform all the apprentice's obligations and duties towards the management of the works and the school authorities, and more particularly:—(1) To show due regard and respect to all persons in authority; (2) to devote himself with assiduity to the acquirement of such knowledge, both theoretical and practical, as is obtainable from the courses; (3) to comply with all the regulations of the school; and (4) to deport himself honestly and respectably.

Art. 3.—On its own part, the Company undertakes to ensure that the apprentice signing this Agreement shall be given such vocational training as should be possessed by a competent moulder or patternmaker.

Art. 4.—Any accident befalling the apprentice shall be dealt with in conformity with the provisions of the Belgian Workmen's Compensation Act of December 24, 1903.

Art. 5.—In addition to the basic wages and the premiums set out in the School's regulations, the Company shall pay the apprentice signing this Agreement a premium of 2,200 fcs. The said premium shall be payable as follows: 250 fcs. at the end of the three months' trial period referred to in Art. 6 hereof, if the apprentice is deemed to be fit to continue attending the courses; 250 fcs. at the end of the second year; 700 fcs. at the end of the third year, provided always that the said apprentice be still a member of the School at the aforesaid times. Moreover, a sum of 1,000 fcs. shall be allowed to every student who, after due completion of three years' attendance at the School, shall have continued in the Company's employ for another two years.

Art. 6.—This Agreement may be rescinded by either party within three months after the signature thereof, subject to 15 (fifteen) days' prior notice. This Agreement may also be determined at any time and without prior notice in the event of serious breach of any of the obligations arising out of its clauses. The fact that an apprentice has failed to obtain half of the marks obtainable for a period of two consecutive months may be treated as a serious breach.

Art. 7.—The apprentice's basic wage shall be at the rate of one franc per hour initially, and increase up to three francs in the case of third-year pupils. The actual increase shall be proportionate to the degree of ability shown by the apprentice. All time spent in theoretical study shall be paid for at the same basic rates as for the time devoted to practical tuition. In addition to his basic wage the apprentice shall, in conformity with the School's regulations, receive a monthly premium calculated on the number of marks obtained by him. The said premium may amount to as much as 30 per cent. of the basic wage. The above rates may be increased in the case of specially deserving pupils, if approved by the Principal of the School. Apprentices will never be required to stop work apart from causes of *force majeure*, such as general suspension of work in the Company's general foundry or pattern shops.

Made in duplicate in .....

Signature of the Apprentice's father or guardian.

For the Compagnie Générale des Conduites d'Eau:

.....

DECLARATION BY THE APPRENTICE.

I, , apprentice moulder or patternmaker, hereby declare that I was present when this Agreement was read over and signed, that my attention was particularly directed to the apprentice's obligations and duties specified therein, and that I undertake to perform the said obligations and duties faithfully and loyally.

.....

Apprentice.

Teaching Corps.

This consists in the first place of two instructors, who direct the practical work carried out in each of the workshops. The theoretical courses (with which the practical work must be brought into harmony) are conducted by members of the Company's staff, who, by reason of their respective functions, have an expert knowledge of the particular branch taught. In connection with each course there is also an examiner occupying a higher position on the Company's staff than the regular teacher, who gives the latter general directions and sees that his instructions are duly carried out. Finally, the school's principal co-ordinates the whole of the work and exercises a sort of benevolent guardianship over the apprentices, whose moral welfare and intellectual training is looked after by him. The Principal receives his instructions from the general manager as far as the technical side of the instruction given is concerned, and from the Staff Supervisor as regards questions of a moral and educational character. There is thus specialisation in the lower ranks of the teaching body, co-ordination by the principal, and mutual control to prevent the training given from being of a "bookish" nature. To prepare the apprentice for his future life, "*non scholæ sed vitæ*," such is the object pursued, and everything contributes to the realisation of this aim.

The Vocation School of the City of Verviers.

The object of the foundry school is to enable owners to find apprentices, who have already received some measure of training, and also to enable engineering students to become familiar with foundry work. To be admitted students must be from 14 to 17 years of age, hold a primary-school education-certificate, enjoy a sound constitution, sign an apprenticeship agreement and effect a deposit of 50 fcs. as a guarantee for the equipment entrusted to each apprentice. Instruction is free in the case of students living in Verviers, but those who live in other communes have to pay certain fees. In certain cases, some civic authorities make a practice of helping local young men to pay their fees.

The complete course occupies one year only, classes being held for 36 hours every week, of which time six hours is devoted to theoretical

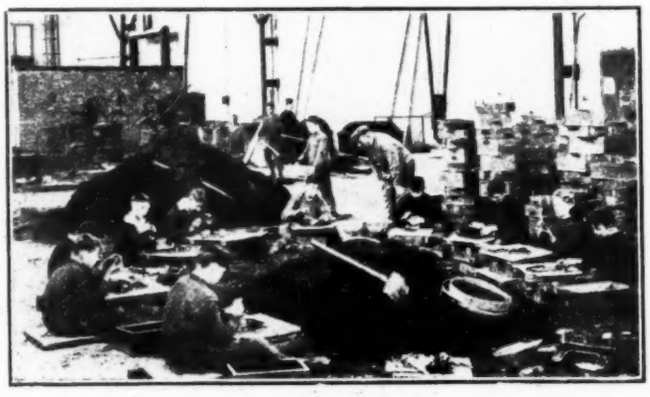

Fig. 13.—Class in Session, Labour University, Charleroi.

instruction, and 30 hours to practical work under the direction of a foreman moulder. Moreover, the pupils must attend the vocational school's evening classes. The foundry technological course is identical with that adopted by similar organisations. The actual castings produced are either marketed in the district, or used for local municipal works or in the School's engineering section. The installation consists of a moulding shop with cupola, moulding and core-making machines, drying oven, and tools for hand work. Another shop is used for sand-preparation purposes. The examination to be passed by the pupils on completion of the course comprises a moulding-operation with a pattern selected by drawing lots, and questions of a theoretical nature in connection with foundry technique. The pupils number about a dozen.

Fig. 14.—Another View in the Foundry at Charleroi.

II.—Courses organised by the Malleable-Foundry Owners' Federation of Herstal.

The Malleable-Foundry Owners' Federation, whose membership embraces all the malleable foundry owners of Herstal, acting on a suggestion made by its president, resolved in 1928 that an effort be made with a view to training and perfecting their foremen and operatives.

Pre-war Position.—In pre-war days, "hand-moulding" was almost the only method utilised at Herstal, and the local moulder was then thoroughly conversant with all the aspects of his craft. In malleable-iron foundries the work was apportioned among various teams, acting, more or less, as regular contractors and very frequently composed of the members of one family, each team consisting of one moulder, one "first lad" (core-maker), and one "second lad" (assistant labourer). No one could become a moulder without having gone through a long period of severe training extending over many years, as "second lad" at first, and subsequently as core-maker. The assistant labourers and core-makers were trained by the moulder, who devoted a portion of his time (frequently after regular working hours) to teaching his assistants what he was wont to describe as the "secrets of his craft." This method had the result of establishing a regular hierarchy among the workers; vacancies in the ranks of the core-makers were filled by the best "second lads," and the most competent core-maker would automatically take the place of the retiring moulder. This method of recruiting labour was extremely advantageous to the masters who, when required, were able to find qualified labour among the men already in their employ.

Post-war Position.—These efforts were reduced to naught as the consequence of the war, from 1914 to 1918; a number of men gave up the trade altogether and others gradually disappeared. The advent of moulding machines increased specialisation in production, and the eight hours' day, introduced after the Armistice, completely upset pre-war methods of work. It gradually became more difficult to find competent moulders, and the training of apprentices was completely arrested owing to the ever-increasing use of machinery and also owing to the unsettled state of the workers themselves.

Although it is evident that the new methods of work no longer necessitate the employment of competent workers in such large numbers as in pre-war times, it is nevertheless true that the hand-moulder is still badly needed in all malleable-iron foundries, were it only for the production of small castings and the preparation of "pattern plates."

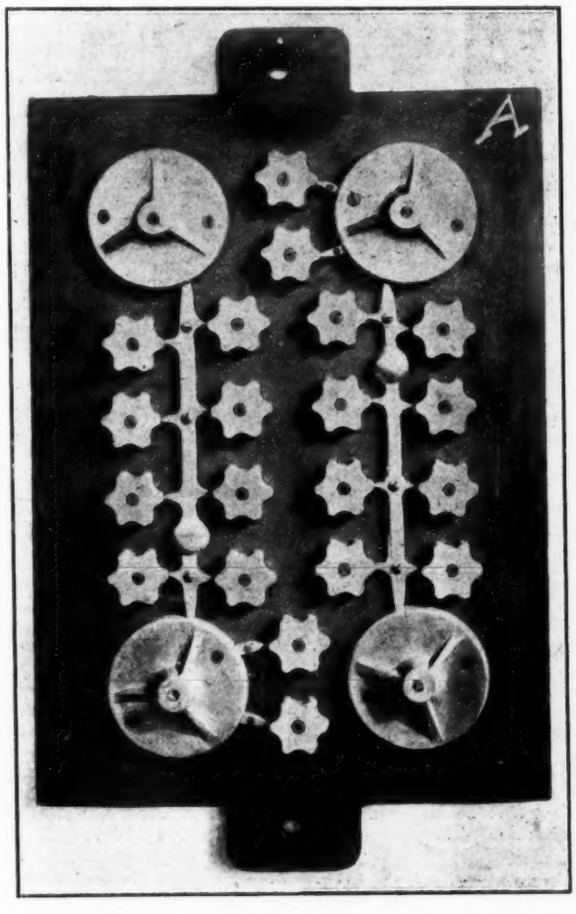

Fig. 15.

The Problem that Confronted the Federation.—In view of the foregoing considerations, the Federation were faced with the following problem:—(1) How to obtain competent moulders by training young men at present employed in the foundries, whose knowledge is obviously below the standard that prevailed in pre-war times among the moulders; (2) how to encourage young men to join the malleable-iron industry by showing them the future possibilities afforded by this particular trade; (3) how to improve the standard, prevailing among labourers, by imparting to them some useful general knowledge of malleable-iron foundry work; and (4) how to propagate a spirit of observation and method among young operatives in the foundry trades. The above statement summarises the problems which the malleable-iron industry will have to solve as far as the recruitment of the necessary personnel is concerned.

Solution of the Problem.—To solve these difficulties in such a specialised centre as Herstal required courage, but the task was certainly well worth trying. The Foundry Owners' Federation almost immediately obtained the support of the workers' unions and of the Permanent Deputation, which latter body placed the Provincial Technical School premises at its disposal It was, of course, quite impossible to deal with such a vast project simultaneously in all its aspects, so that it was decided to organise in 1928-1929 a series of courses or lectures which all workers, young and old, foremen, foundry managers and owners, were invited to attend.

The main object of this procedure was to determine with accuracy both the extent and the quality of the attendance, and also to gauge what measure of interest would be evinced by those who were expected to attend these popular lectures. It was agreed, however, that there should be formed a special category for "regular students," recruited from the persons attending. Apart from fixing the minimum age at 18, no restriction was made as to the registration of the regular students. The principle of examinations was provisionally rejected, and it

was resolved that scholarships should be granted at the end of the year to those students who had attended four-fifths of the lectures. The Committee decided that the courses would be held every Tuesday from 7 to 8.30 p.m., the first hour being devoted to a full exposition of the subject and the remaining half-hour to a general discussion. A summary of each course or lecture was to be handed to each of the persons attending.

The programme consisted of the following lectures:—(i) Inaugural address on "The History and Evolution of Malleable-iron Foundrywork," (ii) and (iii) the study of sands; (iv) the elements of moulding; (v) hand moulding (lecture given in the local dialect by a working moulder); (vi) the moulding of special castings (lecture given in the local dialect by a working moulder); (vii) the production of plaster casts; (viii) the manufacture of "pattern-plates"; (ix) the utilisation of "pattern-plates"; (x) moulding machines; (xi) core-making (lecture given by a working core-maker); (xii) comparative study of various melting methods; (xiii) raw materials for malleable iron, first stage; (xiv) core-boxes and core-making machines; (xv) the pouring of moulds; (xvi) raw materials for malleable iron, second stage; (xvii) annealing furnaces; (xviii) accidents and precautions; (xix) the control of production; tests; (xx) foundry wasters; (xxi) upkeep and maintenance of plant; (xxii) shrinkage and blow-holes; (xxiii) Black-heart malleable iron; the future of malleable iron; and (xxiv) Taylorism in foundries.

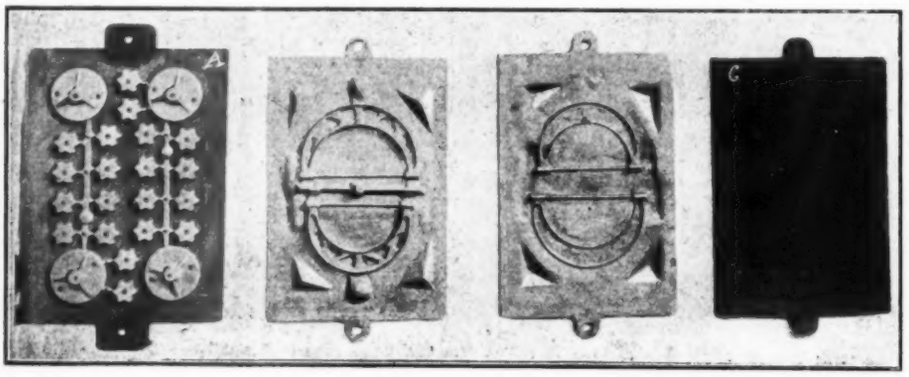

Fig. 16.

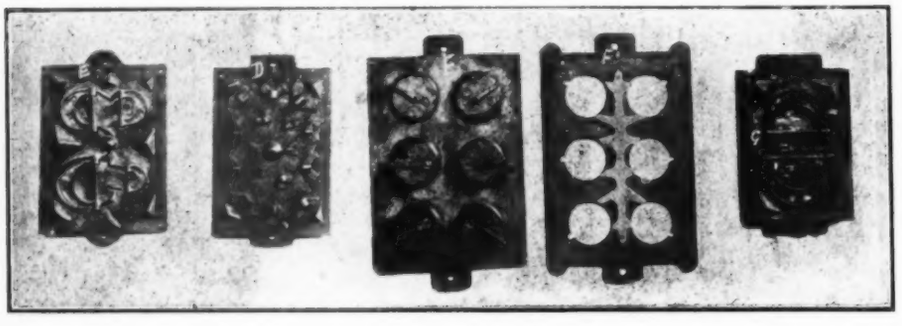

Fig. 17.

The first 21 lectures were attended by 764 persons altogether, i.e., 406 regular students and 358 others, which gives an average of 36 attendances at each lecture. The variety of the subjects treated and the fairly-advanced character of the courses were bound to bring about a certain falling-off in the attendance of regular students. Thirty-five regular students were entered at the first lecture, and after the twenty-first lecture there remained 17 students altogether, 10 of whom had attended four-fifths and 7 seven-tenths of the lectures.

The Foundry Institute of Liége.

The Foundry Institute of Liége, under the direction of Mr. Ivan Lamoureux, a retired foundryman, has created a correspondence course for instruction in the technical side of foundry work. The students are given a very complete course, issued in the form of a quarto volume, containing 270 pages of matter and 325 illustrations. The course is divided into 34 lessons, with 34 questionnaires. Each questionnaire is drawn up in such a form as to compel reflection and application of the lessons on the part of the pupil. The replies sent in by each pupil are corrected and commented upon by the Foundry Institute. The essential part of the instruction bears upon moulding practice. The normal duration of the course is one year. At the end of the course, the students have to pass a *viva-voce* examination at the Foundry Institute, and if they are deemed to have acquired a sufficient knowledge of the subjects taught, they are awarded a foundry technologist's certificate. The object of the Foundry Institute is to give technical training to managers, owners, foremen and workers living too far away from the various schools in existence to attend there, or having no time to avail themselves of the instruction given at certain centres. The Foundry Institute works in conjunction with correspondents in France, Spain and Italy, who co-operate in the distribution of its courses and in the propagation of technical knowledge in connection with foundry work.

The Arts and Crafts School of Pierrard-lez-Virton.

The Pierrard-lez-Virton Arts and Crafts School was founded in 1900 on the lines of similar training centres already existing in France, so that in the same manner as Châlons, Aix and Angers, Pierrard was equipped with a foundry, a pattern-shop, a forge and an engineering section. Its founders instituted bold guiding principles, which have been followed by the School up to the present day. Their intention was that the workshops should be organised on commercial lines, for they were convinced of the impossibility of producing practical operatives and production engineers if their training was directed only in order that their work might be shown at an exhibition held at the end of the year. The students are accordingly trained so that ultimately they may specialise in foundry work. This training extends over a long period, during which the students have to deal with every branch of the trade, such as sand preparation, core-making, moulding, cupola work, preparing the charge and the cleaning of castings for four hours a day for a couple of years, under the supervision of expert foremen having sufficient technical knowledge to enable them to apply in actual foundry practice the theories expounded in the lessons by the two graduate engineers. These lessons, among other things, deal with the calculation of mixings for cast iron and general organisation, also covering certain subjects such as casting, rate fixing, costing, etc. A course in metallurgy, conducted by a university-trained metallurgist, is provided for the purpose of giving a general technical training. Finally, laboratory work, attended by the students for half a day every week, complete the training received by the future foundry manager.

In order that the foundry may produce commercially, it is necessary that the students should have the practical assistance of experienced workmen, for it is evident that the work turned out by the pupils themselves cannot be remunerative. As a matter of fact, such is not the object pursued by the School, since the students attend in order to obtain training and not for gain.

The Arts and Crafts School has been able to furnish foundries in Belgium, France and the Congo with a number of well-trained foundry managers, who have proved a great credit to the School. The students themselves have also realised that special training in foundry work offers good openings for the future, and they are, accordingly, taking up foundry work as a speciality in increasing numbers. It is, therefore, proposed shortly to enlarge the School's foundry on up-to-date lines, while retaining the training principles and methods of instruction hitherto applied.

Scrap for Steel Making.

Inquiry to be Merged in Larger Investigation.

Sir Roy Wilson has retired, on medical advice, from the chairmanship of the committee appointed by the Board of Trade to inquire into the position as to the supply of scrap for steel-making. In view of this, and of the appointment by the Prime Minister of a sub-committee of the Committee of Civil Research to inquire into the iron and steel industries generally, it has been decided to merge the scrap inquiry in the larger investigation. The sub-committee will accordingly give special consideration to the question of the use and supply of scrap. As already announced, its members are the Lord Chancellor, Mr. Thomas Shaw, M.P., Sir Cecil Budd, Mr. C. T. Cramp, and Sir William Plender, with Mr. A. F. Hemming and Mr. W. Palmer as joint secretaries, to whom any communications should be addressed at 2, Whitehall Gardens, London, S.W.1.

Iron and Steel Output in July.

The National Federation of Iron and Steel Manufacturers report that the number of furnaces in blast at the end of July was 167, an increase of two since the beginning of the month. The production of pig-iron in July amounted to 671,900 tons, compared with 657,800 last June and 537,800 tons in July, 1928; last month's production included 208,600 tons of hematite, 283,800 tons of basic, 132,000 tons of foundry and 21,000 tons of forge iron.

The July output of steel ingots and castings amounted to 804,800 tons, compared with 830,900 last June and 666,900 tons in July, 1928.

Coal-Dust in Moulding Sand.

CONFERENCE DISCUSSION REVEALS MANY NEW VIEW-POINTS.

The Origin of Pock-marking.

Mr. Ben Hird's Paper* to the International Conference gave rise to an important discussion as to the action of coal-dust in moulding sands. It was opened by Mr. F. J. Cook, who in a tribute to Mr. Hird, said that those who knew him appreciated the uncanny originality of his methods of approach to any subject; nobody but Mr. Hird would have thought of putting a window in a mould in order to see what happened inside, but by that, as by some of his other unorthodox methods, he had proved many things we did not know hitherto. Referring to the pock-marking of the skins of the castings, he said that this was a great nuisance to those who had to make articles such as stove grates, which had to be used in the condition in which they left the moulds. On one occasion he had been asked to investigate the cause of this trouble, and he had not attributed it to the coal-dust in the sand, but had proved conclusively that it was due to the presence of large grains of raw sand in the facing sand. Often one found that the men engaged in sieving sand on to the face of the pattern were inclined to push the sand through the sieves; he had found that in the particular foundry concerned there was one man whose work was more pock-marked than that of the others, and that this man, not having time to sieve the sand through, was pushing it through; in addition, some of the strands of the sieve were broken. The proprietors of the foundry concerned were not quite convinced that the pock-marking of the castings was due to the presence of large grains of sand. In order to prove the point, he had riddled some sand and had made a mould partly with riddlings and partly with fine sieved sand; when a casting was made in that mould it was found that in the part in which riddlings were used there was pock-marking, whereas in the other part, where the fine sieved sand was used, there was no pock-marking whatever. It was obvious, therefore, that pock-marking was due not only to the use of coarse coal-dust, but also to the presence of large grains of raw red sand. That did not disprove anything that Mr. Hird had said. He considered Mr. Hird was wise in carrying out his experiments with raw red sand only and in avoiding the use of black sand with it, because he had avoided contamination of the sand, and it was wise to introduce as few variables as possible when carrying out research work. If he would give some idea, however, of the additions of black sand permissible in order to obtain the best results, the information would be a useful guide to foundrymen generally.

Coarse Coal-Dust also Pock-marks.

Mr. A. R. Bartlett (London) agreed with Mr. Cook that the pock-marking of the skin of the casting was not due altogether to the use of coarse coal-dust, and said that a far greater degree of pock-marking resulted from a clay-bonded than from a rock-bonded sand of the red-sand type. He used Erith sand, which was clay-bonded, and on castings which were made by men whose practice it was to rub the sand through the sieves there was invariably much deeper pock-marking when a clay-bonded sand was used as compared with a red sand. Naturally, on account of cost, he was anxious to use the local Erith sand as much as possible, and in order to overcome the pock-marking difficulty it was his practice to use the clay-bonded sand mixed with an equal proportion of rock-bonded sand. The use of a coarse coal-dust in the sand also produced pock-marking, of course. At his foundry they ground their own coal-dust, and it was noticed that as soon as the sieves used for grading it became worn, considerable pock-marking of the castings resulted.

Mr. H. B. Hanley (U.S.A.) said he had come into contact with so-called pock-marking in America, and had found that in many cases it was due to the balling up of the binding substance of the moulding sand when the sand was improperly tamped.

Coal-Dust and Venting Properties.

Mr. H. Field, who was anxious to make it clear what was meant by "pock-marking," said he gathered that the appearance of the pock-marks was similar to that of Brinell impressions.

Mr. Hird said that was so.

Mr. Field, continuing, said that he had experienced trouble due to the pock-marking of the surfaces of highly-finished castings, but he did not think it was due to the use of coarse coal-dust, because it was almost impossible to find any coarse particles in the superfine coal-dust used to-day. He did not say this as a contradiction of Mr. Hird's argument, but merely to point out that Mr. Hird's explanation did not appear to fit his own experience. Mr. Hird had stated that in general it was best to use the finest possible coal-dust in order to produce a casting with a good skin. On the other hand, we were told by researchers into sand problems that it was inadvisable to use sand mixtures containing sands of varying grain size, because the fine grains would fill up the cavities between the coarser grains, and less efficient venting would result. He asked whether, if a fine coal-dust were used, the fine grains of coal would fill the cavities between the sand grains, and, if so, why better venting properties were obtained with a fine coal-dust than with a coarse coal-dust.

Volatiles in Coal-Dust and Skin Effects.

Mr. H. B. Hanley (U.S.A.), in expressing appreciation of Mr. Hird's valuable contribution to our knowledge of coal-dust as applied to moulding sands, said the ground was covered more thoroughly by this Paper than by any previous contribution he had seen. The use of coal-dust, he continued, was a matter of considerable importance in the foundry. It was very easy to introduce difficulties by the use of an excessive amount of it, and also by the selection of the wrong grade or particle size. He was particularly interested to note Mr. Hird's remarks concerning the occurrence of pock-marks, and his own experience was in accordance with that of Mr. Hird. It was also quite a common experience to find manifestations of pin-holes in castings when coarsely-ground coal was used in fine moulding sand. Mr. Hird's method of procedure in studying the behaviour of coal-dust was very illuminating, and the work had been carried out in a painstaking and comprehensive manner. His theory relative to the function of coal-dust and its effect upon the surface of the castings was also interesting. There had always been difference of opinion amongst foundrymen as to whether the residual carbon contained in the sand was responsible for the production of cleaner castings, or whether the volatile carbon generated under the action of heat was the beneficial agent. For the want of more information, he had regarded the latter reaction as of first importance. Further, he believed that the chemistry of the reaction between the bonding substance and the volatile gases under the action of heat was very much responsible for the peeling phenomenon observed in many sands. One had only to note the colour of the changed mass after the casting was made to recognise the influence of the carbonaceous material upon the ingredients of the facing. It appeared quite clearly that a chemical change of considerable importance occurred in the reducing atmosphere.

Referring to the grade of coal to be used in practice, he said that Mr. Hird leaned towards the use of finely-ground coal. One advantage of the use of finely-ground coal—by which he meant coal ground so finely that 90 per cent. or so would pass through a 100-mesh sieve—was that less of it was used to do the work than would be used if it were more coarsely ground, but, on the other hand, it was well known that the finer coal acted as a filler in the facing, and consequently lowered the permeability. Measurements had shown that finely-ground coal in green-sand practice contributed a slight increase in bond and a desirable smoothness to the sand. The opinion had been expressed from time to time that ground coal increased the permeability of facing sand. No doubt the coke produced by the incomplete combustion of the coal increased the voids, but it was hardly possible to conceive of an increase in permeability. The amount of gas generated when ground coal was present rendered good permeability of the sand more necessary than ever. The more coarsely-ground coals were used as a rule only for the making of medium and heavy castings. In America five or more grades of sea coal were used in the foundry. The analysis conformed generally to the following composition:—Moisture (as received), 1.30; volatile matter, 33.96; fixed carbon, 55.46; ash, 9.28; and sulphur, 1.27 per cent. The percentage of volatile carbon seemed to be a little higher in those coals than in the coals he had seen in Mr. Hird's collection at the Foundry Exhibition. The average fineness numbers of the American coals referred to were 128, 142, 189 and 272, and there was a still finer grade called "air-floated" material. The coarser grades were always used by the manufacturers of heavy castings in grey iron; the medium and fine grades were used extensively in the medium grey iron and malleable shops. The finely-ground (but not air-floated) material was being used more and more, and that was in accordance with Mr. Hird's recommendation.

There were, of course, a number of natural sands in America whose bond content was so very low that the use of ground coal with them was not called for. On the other hand, some of the American sands, carrying a sticky bond, would not produce clean castings in green-sand practice without the addition of one part of ground coal to ten or twelve parts of sand. In malleable foundries cleaner castings were produced when ground coal was used than when it was not used; the greater temperature of the iron made necessary the use of sea coal.

The producers of sea-coal facing—as it was called in America—marketed their grades under standard specifications, and generally the product could be relied upon as regards uniformity of grade and chemical composition.

Finally, Mr. Hanley expressed the hope that Mr. Hird could continue his investigations, in order that we might appreciate fully the rôle played by powdered coal in its various applications to foundry practice. Mr. Hird's work was of high calibre and of great value to the industry.

Cushioning Effect of Coal-Dust.

Mr. J. G. A. Skerl (British Cast Iron Research Association), in congratulating Mr. Hird upon his work, carried out more or less in his spare time, said that the industry could do with the help of many more men of his temperament and ability, to carry out experiments which might be thought to be quite simple, but which were necessary to the advancement of foundry technique. The technical literature of the foundry industry lacked Papers concerning the addition of materials to facing mixtures. The work of the Research Association would be confined practically to laboratory work, because the Association had no foundry of its own, unless members and others in the industry carried out experimental work in connection with

* See our Issues of June 27 and July 4.

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sands, and such co-operation was welcomed by the Association.

Stourbridge red sand had been used by Mr. Hird for the purpose of his experiments, and it was to be expected, of course, that when casting into virgin Stourbridge red sand—which was a good and strong sand—one would obtain a bad casting in the first place: the metal would not lie on this strong sand, and the skin of the casting would be rough. If coal-dust were used with the sand, undoubtedly the metal would lie on the mould, by reason of the cushioning effect produced by the coal-dust. Mr. Hird had the honour of being the first to have published the results of some permeability and strength tests carried out by methods put forward by the British Cast Iron Research Association. Those methods would be published shortly.

Grading Difficulties.

Discussing the fineness of grinding, and sieving, he said Mr. Hird had used a fine, a medium and a coarse grist. It would appear, however, that his fine grist was equivalent to the medium grist of most coal-dust producers; the superfine grist produced by the big firms was very much finer than the fine material used by Mr. Hird. With regard to the ratching effect referred to in the Paper, he suggested that this might be due to a large extent to the fact that the sand was too strong, and, being green sand, the action of the metal would cause the sand to shrink, so that cracks were formed, into which the metal could penetrate.

Relative Carbon Absorption by Steel and Cast Iron.

In the section of the Paper dealing with carbon absorption, Mr. Hird had proved satisfactorily that a certain amount of the carbon was taken up by the skin of the metal from the coal gas. Then he had stated: "This is probably the reason why coal-dust, added to the sand for facing mild-steel castings, does not operate in the same way as it does with high-carbon steel and grey-iron castings." Mr. Skerl asked for a more detailed explanation of this statement, because he believed that a mild steel would take up more carbon, inasmuch as it contained less in its original state. The probable reason for the non-absorption of carbon in mild steel was that its freezing range was shorter than the metals containing higher carbon percentage.

Dealing further with the question of grain size, he recalled the claim of research workers—already mentioned by Mr. Field—that the size of the particles of coal-dust used should be practically the same as that of the sand grains, and said that Mr. Hird's results had confirmed that, because the grading of his superfine or fine coal-dust was very similar to the grading of most moulding sands.

The Tarry Constituent of Black Sands.

A point which Mr. Hird had not emphasised particularly was that much of the black material in black sand was mainly tarry matter, and not carbon. He (Mr. Skerl) had proved that quite 50 per cent. of the black material in a moulding sand which had been used was definitely tarry material; it was soluble in various reagents, whereas carbon was not. He urged Mr. Hird to continue experiments on dry-sand moulds, because it seemed to him that in the experiments so far carried out no account had been taken of the effect of moisture. Judging from the contents of Mr. Hird's Paper, one would expect the same things to happen in a dry-sand mould as in the others, but one knew from practice that that would not be the case. The effect of moisture in this connection would have to be considered sooner or later.

Coal-Dust in Green-Sand Castings.

The Paper did not settle the question as to whether or not the use of coal-dust was advisable in green-sand mixtures. Varying opinions were held in this country with regard to this matter. Some five years ago he (Mr. Skerl) had read a Paper before the Sheffield Branch of the Institute of British Foundrymen, in which he had discussed the effect of coal-dust, horse manure and other things on facing mixtures, and had pointed out that there was no real reason for the addition of these materials to a properly-prepared sand. Since then he had become more certain than ever that coal-dust, horse manure and such materials were not so necessary in foundries to-day as we were inclined to think they were. He had visited foundries in which green-sand castings weighing up to 2 tons were made without the addition of coal-dust to the sand, but it was interesting to note that the mixtures in which these castings were made were always weak, as compared with the ordinary green-sand mixtures used in most foundries. Most foundrymen would consider such weak mixtures unsuitable for the class of work for which they were used, but there were some who held the view—which he believed was held also by some of the American visitors to the Congress that most of the ordinary green-sand mixtures used in this country were very much on the strong side, having in view the work for which they were used. Some time ago an opportunity had arisen to test the argument that coal-dust was not necessary in green-sand moulds. As part of the routine of the Association, it was the practice to test the surfaces of castings as affected by the moulding sands by making fairly large castings, weighing up to nearly 1 cwt., and 1, 2 and 3 inches thick, in the virgin sands. Erith sand was one of the sands tested. There were five grades of Erith sand—mild, very weak, yellow (weak), medium-strong grade and extra-strong grade. The mild and yellow sand would not be accepted by any ironfounder because of their lack of bond. The castings made in the very weak sand had as good a skin as one could wish for, but those made in the progressively stronger sands were badly marked. When coal-dust was added to the sands in varying proportions, the skins of the castings were not so good as that obtained with the weak sand alone, so that there was some basis for the view that coal-dust was not definitely necessary in moulding sands, and that the treatment of a moulding sand had a far greater effect on the surface of the castings than we had believed hitherto. A properly-prepared sand, without coal-dust, would produce as good a casting as, and often better than, a sand containing coal-dust.

Mr. Skerl hoped that many members would experiment with their green-sand mixtures by varying the percentage of new and old sand and with varying percentages of various grades of coal-dust, and contrasting the results obtained. It was only in this way that they could get the best out of Mr. Hird's Paper.

Coal-Dust Deemed to be Unnecessary.

Mr. J. M. Primrose (Falkirk), discussing generally the practice of adding coal-dust to moulding sands, pointed out that gas in a mould was a source of great trouble and danger, yet the foundryman added to the sand something that would produce more gas; further permeability was very desirable in a mould, yet the foundryman added something to the sand which helped to block up the vents; bond was an important factor, yet the foundryman added something which was deleterious; economy was necessary in the foundry—all castings were said to be 10s. per ton dearer than they ought to be, no matter how cheap they were—(laughter)—and yet we added something which would increase the cost of the castings. For generations foundrymen had been adding coal-dust to moulding sands, not because there was any sense or reason in it, but because their grandfathers had done so, and he was quite positive that, so far as his business of producing light castings was concerned, coal-dust was not required. One saw people preparing sand in automatic mixing machines for the making of light castings in moulding machines, and one saw them adding coal-dust and blacking, but he did not think they knew why they were adding those substances; he had made light castings for years without the use of either coal-dust or blacking. He might be asked "Where is the blue skin?" but his reply was that he was producing grey-iron castings, not blue ones. (Laughter.) If we were going to add blacking in order to produce a wonderful blue skin, why not go the whole hog and produce castings with yellow, green, red and other coloured skins? (Laughter.) At the same time, Mr. Hird's Paper was valuable, because in it a practical man had given reasons why he considered coal-dust was necessary in moulding sand, but he would like another practical man to write a Paper and to state the reasons why coal-dust was not required, because he believed that ultimately sands would be properly prepared and coal-dust would then not be required at all.

An Inverse Action.

Mr. S. H. Russell (Past President), whilst agreeing that the investigation carried out by Mr. Hird was of extreme value, joined issue with him on what seemed to be one of his fundamental points. Mr. Hird had failed to convince him that it was the coking of the coal particles that caused the phenomenon to which he had referred. For instance, he could not agree that the mapping, which had occurred when using a mixture containing three parts of coal-dust and ten of red sand, was due to the expansion of the coke formed in the sand. In this case there was a sphere or cylinder of molten metal in a closed mould with a head of molten metal on it, and there was therefore fluid pressure. In the sand surrounding the molten metal there was merely the pressure generated by the gases; the sand was more or less self-venting and the pressure amounted to only a few pounds, and it was obviously very much lower than the great pressure exerted by the molten metal. It seemed to him that probably the mixture of three parts of coal-dust and ten parts of sand was, from a foundryman's point of view, a ridiculous mixture. There was too much coal-dust. Was it not conceivable that, instead of the coke expanding and cracking the mould, the opposite action occurred, *i.e.*, that the molten metal rapidly attacked the large surfaces of coal, penetrated between them and pushed the sand before it, so that the action was outwards and not inwards; that the metal forced its way through the bonded sand, breaking it up, burning the coal out, and then forcing its way farther. In another case, even when using what was called a superfine coal-dust, Mr. Hird's theory was that this coal-dust was converted into coke near the skin, but he (Mr. Russell) was not so sure that that was so. It was somewhat difficult to criticise, because the Paper contained no definition of "superfine coal-dust," and he did not think that Mr. Hird and himself would quite agree as to what was a superfine coal-dust; what he himself called a "superfine" coal-dust was one so fine that one could not retain it in the palm of the hand in a strong draught. Mr. Hird has stated that superfine coal-dust was the most efficient for heavy as well as for light work, and that coarse-graded coal-dust was not satisfactory, but if he (Mr. Russell) used his superfine coal-dust in the moulds for making castings weighing two tons he could not turn them out at all; it was not used for castings weighing more than a few pounds.

Instantaneous Combustion of Coal-Dust.

He visualised that the process in the mould was somewhat similar to the process in the burning of powdered fuel, *i.e.*, that the combustion was almost instantaneous; he suggested that the particles of coal in the mould were so minute that they had not time to coke, that they were converted almost entirely into gas on the surface of the mould, and only a very small proportion of ash remained, and he could not conceive that the coal-dust could give rise to the pock-marks after the mould had filled. In his view the

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pock-marks were due to the presence in the facing of coarse pieces of sand which had been rubbed through the sieves, which coarse pieces, he believed, contained a very large percentage of clay bond; the action of the metal on the clay bond was to produce a small bubble, which was retained there from the moment the metal had flowed over it, and could not get away owing to the large quantity of clay there and the consequent lack of permeability. It seemed inconceivable that sufficient pressure could be produced in the sand to force anything from the sand into the casting and produce the pock-marks.

Mr. Russell also joined issue with Mr. Hird with regard to the refractoriness of black sand. Mr. Hird seemed to have suggested that it became more refractory because it had been coated with deposits from coal-dust, but he himself believed that any refractoriness in black sand was due entirely to the enormous amount of actual coal-dust in it. Anybody using moulding machines, particularly of the hand-rammed or push-off variety, would notice the tendency for the men to use an excess of facing sand because it contained a bond and the moulders more easily obtained a good lift.

Standardisation of Size Chaotic.

Mr. H. Winterton expressed gratitude to Mr. Hird for having studied the action of coal-dust in moulding sands so thoroughly and for having arrived at conclusions which were likely to lead somewhere. He recalled that in a Paper he had presented to the Birmingham Branch of the British Foundrymen's Association twenty years ago he had stated that a reasonable percentage of volatile matter in the coal-dust was about 30, and he was pleased that Mr. Hird had confirmed that. With regard to the grists adopted by Mr. Hird, he suggested that they were somewhat weird, and were certainly very much coarser than those which he (Mr. Winterton)—as a manufacturer on a large scale—had been endeavouring for many years to make standard. The chemist at his Chesterfield laboratory had stated that the tests showed definitely that all the superfine coal-dust they produced would pass through a 90-mesh sieve, and 90 per cent. would pass through a 110-mesh sieve, so that it was much finer than the superfine coal-dust referred to by Mr. Hird. There should be a standard to work to and an insistence that coal-dust, no matter by whom it was supplied, should conform to that standard. He believed that the sea-coal facing in this country was of better quality, considering the requirements of the foundry, than that obtainable in America. The grists supplied in this country to-day were more regular than the American, judging by the specimens he had seen there. The more we could co-operate in these matters, the better for all concerned, and he emphasised that it was the desire of all the suppliers of these materials to meet the requirements of the users fully, and not to foist upon them anything which might add to the already too numerous troubles of the foundry. He hoped sincerely that, as a result of Mr. Hird's further investigations, coupled with those which were being carried out from day to day in the laboratories of the manufacturers, we should arrive at a satisfactory basis in the not far distant future.

Mr. F. J. Cook, discussing the phenomenon of mapping, said he did not think a true explanation of it had been put forward either by Mr. Russell or Mr. Hird. It could be seen better, perhaps, in a dry-sand mould than in any other. If one made a dry-sand mould—such moulds were usually made with very strong sands—and baked it rapidly, the surface of the mould would exhibit the mapping which was exhibited on the casting referred to by Mr. Hird and unless it were filled up with blacking, the casting made in that mould would have a similar marking. It was due to the contraction of the sand under the influence of heat, and he believed that was the true explanation in moulds other than dry-sand moulds also.

AUTHOR'S REPLY.

Mr. Hird, replying to the discussion, said he had endeavoured to record conscientiously the experiments he had made, and his conclusions were his summing up of the results obtained. He admitted he had only touched the surface of this subject, and hoped that others would carry out further experiments with coal-dust facing sands, and give their findings of its effect on the casting skin and the sand. They might prove, or disprove, some of his statements, but it would all add to the general knowledge. He would be pleased to collaborate as far as he could with anyone who took up the subject. Specimens of his experiments were exhibited in the Science Section of the Exhibition, and he would like to meet there anyone who was interested and discuss the results. With regard to the grists, the three grades used were adopted for experimental purposes, and suited the sieves at his disposal. His Paper represented an ordinary foundryman's attempt to deal with one of the many troubles encountered in the foundry, and he sincerely hoped that others with better facilities at their disposal would carry further the investigations he had begun.

Pock-marks due to Coal-Dust.

Replying to Mr. Russell's criticism about the cause of pock-mark, he maintained his statements in the Paper and indicated that he would be pleased to meet Mr. Russell at the Exhibition to examine the specimens exhibited there (subsequent examination of one of the pock-marked castings convinced Mr. Russell that the author's statements were correct, as under low magnification a speck of coal transformed to coke could be seen embedded in a pock-mark).

Dealing with the remarks of Mr. Primrose, he agreed that coal-dust created more gas, and therefore it must tax the permeability of the sand to a greater extent. The addition of coal-dust to sand coated many of the sand grains with carbon, which destroyed the alumina bond.

He did not agree with Mr. Skerl's remarks with regard to Stourbridge red sand. The grade used in the tests under discussion had been used in his (Mr. Hird's) foundry for many years—it was of medium fineness of grain and bond, and very seldom milled. Trouble on a certain job, where the liquid shrinkage caused a drawhole owing to the unequal section of the casting, had been almost eliminated by facing the heavy section with raw red sand. His theory was that the coal-dust in the sand helped to maintain the heat of the metal, and therefore in comparison the raw red sand acted as an incipient chill. With regard to ratching, the trouble was usually found on that part of the casting formed by the bottom and lower parts of the mould. He had carefully removed some of the ratching and examined it under a low-power microscope, which revealed specks of coked-coal with all the pores filled with metal, and on this he based his conclusions. The theory of carbon-absorption by the casting from the coal-dust in the sand developed in his mind when thinking over a statement made to him by Mr. W. B. Lake, of Braintree, to the effect that coal-dust in the sand gave no results on mild-steel castings, but Mr. Lake had found it operated in helping to skin and strip castings made of special high-carbon steel. The author had only made the one experiment given in his Paper, and he would appreciate it if someone with better facilities than he had would carry out similar experiments to check this theory. Also if someone would define more clearly the difference of the three distinct carbon deposits left in the mould by the decomposition of the coal, viz.:—(*a*) The free bright silvery carbon flakes on the face of the casting, (*b*) the silvery carbon coating the sand grains in the coked portion of the skin sand, and (*c*) the dull-black tarry deposit on the sand grains behind this part. This would materially help the foundryman to understand the composition of his black sand, which composed the bulk of the sand used in most foundries. With regard to the amount of coal-dust left in the black sand, he had had an analysis made for free coal-dust, taken from a sample off the foundry floor: the result showed that there was only 0.5 per cent free coal-dust left in the sand, although in appearance it was quite black.

Commenting on Mr. Field's suggestion that pock-marking was due to something other than coal-dust, he said that in his experiments he had not discovered anything other than coal-dust to account for the pock-marking. The red sand was carefully dried and sieved through the same fine-mesh sieve for all experiments, and, with the exception of water, nothing other than coal-dust was added, and the latter was the only variant. The results he had obtained fully supported his theory, and he suggested that Mr. Field and he might, with advantage, study together the specimens being shown at the Exhibition.

With regard to the venting, or increased porosity of the sand, due to the addition of coal-dust, he thought this was a subject for further research. In his opinion the idea of adding coal-dust to sand to increase the porosity was wrong. The addition of very fine coal-dust, such as he advocated, must block some of the pore spaces formed by the sand grains, and the gases given off would also add extra duty to the pore spaces. Again, the swelling of the specks of coal, when suddenly changed to coke, tended to pack the sand grains closer together (as instanced in the case of mapping). Further, these beads of coke, when crushed to fine particles by the working of the sand, form fine silt (or dust). On the other hand, the specks of coke remaining whole would have a far greater porosity than the grains of quartz sand. Yet, despite the above points against very fine, high-volatile coal-dust, in the whole of the tests made on soleplates, only Nos. 13 and 16 showed any sign of scabs. These were made with 5-per-cent. additions of coarse grist, low-volatile coal-dust.

Replying to Mr. Bartlett, he agreed with him that the coarse coal-dust would produce more pronounced pock-marks in the casting when a tough clay-bonded sand was used. The strong sand would offer greater resistance to the sudden swelling of the coal grain as it changed to coke, causing it to swell outwards from the mould face, and press deeped into the skin of the casting.

Replying to Mr. Hanley, he did not encounter this balling up of the bonding clays in strong facing-sand, but nevertheless could not see how this would cause the same type of pock-marks which he had obtained with coarse coal-dust.

Concluding, Mr. Hird said he could not find words to express adequately his thanks for the very kind appreciation which the members—particularly Mr. Hanley—had given to his Paper, and it made him feel recompensed for all the work he had put into it. Finally, Mr. Hird paid a tribute to Mr. Cook, and said that it was due to his intuition that this Paper was presented to the Congress. He (Mr. Hird) had intended to present the Paper to a Branch meeting, but Mr. Cook had urged that, in view of the importance of the subject matter, it ought to be presented to the Congress. He wished publicly to acknowledge the help he had received from Mr. Cook in connection with his experiments.

On the motion of the Chairman, a hearty vote of thanks was accorded Mr. Hird for his Paper.

Continental Steel Cartel.

The meeting of the Continental Steel Cartel has been postponed from September 12 to 26, the place of assembly being Vienna. The committee appointed at the last quarterly meeting has met to consider the future of the Cartel and the proposals submitted by the various groups. At present statistics concerning each group are being collected. The current agreement expires at the end of October and a provisional prolongation is expected pending a definite decision as to the future of the Cartel.

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Trade Talk.

THE WHITFORD STEEL SHEET AND GALVANISING WORKS, Briton Ferry, which had been idle for three months has now been restarted.

THE HOHENZOLLERN COMPANY at Düsseldorf are closing down their locomotive works there, and transferring the business to the Krupp works at Essen.

THE MILLOM AND ASKAM HEMATITE IRON COMPANY, LIMITED, announce that iron-ore shipments at Almeria from their Alquife mines in July totalled 30,650 tons.

MESSRS. SHORT BROTHERS, LIMITED, Sunderland, have received an order to build for Messrs. Charlton, McAllum & Company, Limited, of Newcastle, a vessel of 6,600 tons.

SWANSEA ENGINEERS & FOUNDERS, LIMITED, are being wound up voluntarily. Mr. C. H. Harvey, Central Chambers, Fisher Street, Swansea, is the liquidator.

IMPERIAL CHEMICAL INDUSTRIES, LIMITED, have decided to close down the Castner-Kellner alkali works at Wallsend, and to transfer the plant and workers to Billingham.

MESSRS. SIR W. G. ARMSTRONG, WHITWORTH & COMPANY, LIMITED, Walker-on-Tyne, have booked contracts for two motor tankers of about 9,000 tons each for Norwegian owners.

THE L.N.E.R. ANNOUNCE that contracts have been placed with Messrs. Henry Lees & Company, Limited, Glasgow, for locomotive coaling plants at Aberdeen, Edinburgh and Kittybrewster.

MESSRS. BROOKS & DOXEY (1920), LIMITED, have decided to transfer the manufacture of textile machinery now carried on by Messrs. Lord Bros. at Todmorden to their Union Works at West Gorton, Manchester.

THE LONDON MIDLAND & SCOTTISH RAILWAY COMPANY have awarded to Messrs. Sir William Arrol & Company, Limited, Glasgow, the contract for widening a railway bridge at St. Mary's, Newton Heath, Manchester.

THE PUBLIC EXAMINATION of Mr. J. H. Knott, carrying on business as J. H. Knott & Company, at Crown Street Foundry, Wolverhampton, iron and brass founder, will take place on October 16 at the County Court, Queen Street, Wolverhampton.

AN EXTRAORDINARY general meeting of Messrs. William Beardmore & Company, Limited, was held in London last week to confirm resolutions passed on July 29, 1929, approving the reorganisation of the loan and share capital. The resolutions were carried.

OWING TO the pressure of work in the wagon department of the L.N.E.R. works, Cowlairs, Glasgow, overtime has been in force since the resumption after the July holidays. Overtime has now been introduced at the rate of three nights per week. This will affect a large number of the employees.

MESSRS. R. A. WALL & A. FRANCIS, carrying on business as steel manufacturers and merchants, at Magneto Steel and Wire Works, Penistone Road, Sheffield, under the style of G. P. Wall, have dissolved partnership by mutual consent. Mr. A. Francis is continuing the business.

MESSRS. HUGHES, BOLCKOW & COMPANY, LIMITED, Middlesbrough, have purchased from the Admiralty for breaking-up purposes the turbine steamer "Princess Margaret," which was built in 1914 by Messrs. Wm. Denny & Brothers, Limited, for the passenger service of the Canadian Pacific Railway Company, and taken over by the Admiralty during the war.

IN CONNECTION with the scheme for the electrification of the railway line between Manchester and Altrincham several large contracts entered into were announced last month. Another has now been entered into with the Metropolitan-Cammell Carriage, Wagon & Finance Company, Limited, Birmingham, for the supply of 24 electric cars, 22 non-driving trailer cars, and 22 driving trailer cars.

THE TWIN-SCREW motor-propelled passenger and cargo vessel "Westralia," launched in April from the Govan yard of Messrs. Harland & Wolff, Limited, for Messrs. Huddart Parker, Limited, Melbourne, ran official trials on the Clyde recently, and attained a speed of almost 17 knots over the measured mile. The contract stipulation was 15½ knots. The vessel will be employed on the owners' Australian service.

FURTHER EXPERIMENTS in the use of steel sleepers, with which it is hoped ultimately to replace a large proportion of the wood sleepers at present used on British railways, are being made by the London, Midland and Scottish Railway. Steel sleepers have been laid down on two selected stretches of track on the main line between Euston and the North. They will probably be taken up again at the end of the year for examination.

THE GREENOCK DOCKYARD COMPANY, LIMITED, Greenock, have received an order from Mr. A. Melville Dollar (Canadian American Shipping Company, Limited), Vancouver, B.C., to build a cargo steamer 420 ft. long, 58 ft. in breadth and of approximately 9,400 tons deadweight. The vessel is intended for service in the lumber trade, and the machinery will be supplied by Messrs. David Rowan & Company, Limited, Glasgow.

THE SOCIÉTÉ DES FORGES ET ACIÉRIES DU NORD ET DE L'EST is finishing at its Louvroil plant the construction of a third blast furnace, which will be blown in shortly. The Société owns, besides, four blast furnaces at its Valenciennes plant, and produced, in 1927, with six furnaces, 572,013 tons of pig-iron. A third open-hearth steel furnace is now nearing completion at the Valenciennes plant, which will double the present production of that grade of steel. Other extensions are contemplated, notably the construction of a basic steel plant at Louvroil.

A NEW INVESTIGATION into the theory of steel structures is shortly to be commenced by the Department of Scientific and Industrial Research. The research is intended to be the most comprehensive ever undertaken, and will probably occupy about five years. The suggestion emanated from the British Steelworks Association, which is prepared to make a financial contribution of £2,000 for five years, which is equal to about half the estimated cost. The other half of the cost will be borne by the Research Department. An authoritative committee, composed of representatives of the Association, the Institution of Civil Engineers, and the Department of Scientific and Industrial Research, with Sir Clement Hindley as chairman, has been formed.

THE CARGO STEAMER "Zitella," the sixth of what is known as the Burntisland 7,750-ton deadweight "economy-type" ship, ran trials recently, when she attained a mean speed, fully loaded, of 11 knots. The engines are of the triple-expansion type supplied by Messrs. David Rowan & Company, Limited, Glasgow, and the design of the ship embodies many special features in regard to form of hull, engines and propeller design. In previous vessels of the type the performances under actual service conditions have shown very low coal consumptions. The contract provided for a speed of 9 knots, with a daily coal consumption not exceeding 19 tons in fully-loaded condition. A six-hour coal-consumption test gave 16.46 tons per day at a speed of 9.08 knots.

THE LATEST TYPE of Yarrow boilers are to be installed in the fast passenger and cargo vessels now being built by Messrs. Cammell Laird & Company, Limited, Birkenhead, for the Canadian National Railways. Each vessel will have six Yarrow boilers equipped with superheaters and air heaters of Messrs. Yarrow's latest design. The firm at Scotstoun are themselves constructing the whole of the installation for the first vessel, and will supply working drawings to enable Messrs. Cammell Laird & Company to construct the boilers for the other two vessels in accordance with Messrs. Yarrow & Company's modern practice. The Yarrow boilers are being adopted to an increasing extent in the mercantile marine, many of the latest liners and cargo vessels having been equipped with them.

THE PETITION presented to the Ministry of Labour recently, signed by the employees of Messrs. William Beardmore & Company's Mossend steelworks and almost all the tradespeople of the district, asking that the Government do something in the way of creating employment at Messrs. Beardmore's, has not so far resulted in any change in the state of affairs at Mossend. When Mr. J. H. Thomas confirmed some time ago that he had been in touch with the firm, there was a feeling of optimism in the district. Hopes of an early improvement have, however, been dissipated by the news that some of the staff were paid off on August 17. It is understood that another effort will be made by the authorities in the district to direct attention to the hardships owing to prolonged unemployment, and to press for a share of the steelwork going on in the country.

Reports and Dividends.

Mansfield Engineering Company, Limited.—Loss for year ended June last of £2,341.

Swan, Hunter & Wigham Richardson, Limited.—Interim dividends of 3 per cent., less tax, on the preference and ordinary shares.

Obituary.

MR. JOHN RITSON, who died at Eston last week, had spent over half a century in the service of Messrs. Bolckow, Vaughan & Company, Limited. He retired about four years ago from the position of chief of the costs department of the company's South Bank Ironworks.

MR. J. C. WARD, one of the leading industrialists in Sheffield, and a director of Messrs. Edgar Allen & Company, Limited, died on August 8. Mr. Ward had travelled all over the world in the interests of his firm. He accompanied Sir Arthur Balfour and other well-known business men to America, shortly after the war, for a conference on the Fordney Steel Tariffs. Mr. Ward was 59 years of age. He was educated in Belfast, and afterwards at Sheffield University and King's College, London. Having served his apprenticeship with Messrs. Harland & Wolff, Limited, Belfast, he joined the staff of Messrs. Hadfields, Limited, Sheffield, and in 1896 became associated with Messrs. Edgar Allen & Company, Limited, as their London representative. In 1908 he was appointed a director, and continued to be a member of the board until his death. He was a former President of the Sheffield Chamber of Commerce, and a member of the Sheffield City Council.

Contracts Open.

Ashford, August 28.—90 tons of 6-in. and 4-in. cast-iron pipes and special castings, for the Urban District Council. The Surveyor, 5, North Street, Ashford, Kent.

Birmingham, August 26.—Machine tools and workshop equipment, for the Electric Supply Department. Mr. E. J. Jennings, secretary, 14, Dale End, Birmingham.

Dover.—Steel and cast-iron gas mains, for the Dover Gas Company. Messrs. Anderson Brothers, 5, Victoria Street, London, S.W.1.

Dublin, August 28.—120 pairs of cast-steel wheels, complete with axles and tyres, and 200 self-contained wagon buffers, for the Great Southern Railways (Ireland). The Company's Stores Superintendent, Inchicore, Dublin. (Fee 2s. 6d.)

Pennard, Wales, August 23.—1,720 yds. of 4-in. cast-iron main, etc., for the Gower Rural District Council. The Council's Offices, 12, Christina Street, Swansea. (Fee £1 1s., returnable.)

Tyldesley, August 26.—Carbonising and coal handling plant, for the Urban District Council. Mr. F. Peel, engineer and manager, Gasworks, Tyldesley.

New Companies.

A. H. Allen & Company (Engineers), Limited, 38, St. Andrew's Street, Northampton.—Capital £4,000. Directors: A. H., A. L., P. J. and L. J. Allen.

Monk, Worsley & Monk, Limited, Chepstow Road, Chorlton-cum-Hardy, Manchester.—Capital £4,000. Engineers, etc. Directors: F. A. Monk and E. T. Worsley.

H. Whitehead (Bradford), Limited, 45, Wharncliffe Drive, Eccleshill, Bradford.—Capital £2,000. Engineers' factors. Directors: H. Whitehead, A. E. Bottomley and W. Bottomley.

Baird, Hughes & Company, Limited, 24, Oswald Street, Glasgow, C.—Capital £500. Metal, steel and hardware merchants, etc. Directors: A. A. McKechnie and F. W. Hughes.

Personal.

MR. B. PURVIS, of Sunderland, has been appointed to the position of Teacher of Pattern-making and Foundry Work at the Woolwich Polytechnic.

MESSRS. WARNER & COMPANY, LIMITED, Cargo Fleet, Middlesbrough-on-Tees, have appointed Mr. G. A. Usher as their representative, in the place of the late Mr. Edward Sillars, who held that post for many years. Mr. Usher was at one time on the commercial staff of THE FOUNDRY TRADE JOURNAL.

Wills.

HAY, GEORGE MORRISON, ironfounder, managing director of Messrs. G. M. Hay & Company, Limited, Strathclyde Foundry, Glasgow, for some time chairman of S.I.A. £70,649

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Nor hath his heart within him burned
And stern, the alien tempter spurned
I'll use no Foreign Sand!"

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"If such there be, go mark him well,
For him no minstrel raptures swell,
High though his titles, proud his name,
Boundless his wealth as wish could claim,
Despite those titles, power and pelf,
The wretch concentred all on self,
Living, shall forfeit fair renown,
And doubly dying, shall go down,
To that vile dust from which he sprung,
UNWEPT, UNHONOURED, AND UNSUNG!"

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Iron and Steel Markets.

MIDDLESBROUGH.—Conditions in the Cleveland iron trade remain, as is likely to be the case during the current month, uneventful in the extreme, the few transactions recorded of late having been quite negligible in quantity and importance. The outlook for the industry, however, is regarded as fairly favourable on the whole to an early expansion of the already progressive demand, as may be noted in the figures given in a recent report of the National Federation of Iron and Steel Manufacturers, stating that the total home production of pig-iron in July amounted to 671,900 tons, compared with 657,800 last June and 537,800 tons in July, 1928; last month's production included 208,600 tons of hematite, 283,800 tons of basic, 132,000 tons of foundry and 21,000 tons of forge iron. Thus, there would appear to be ample grounds for confidence in the future of the industry, and in that spirit neither Tees-side merchants nor ironmasters are endeavouring to force the pace at an inopportune moment. Such small home orders as come along are welcomed, and for the rest they are prepared to mark time. Meantime, prices remain very firm as follow:—No. 1 Cleveland foundry iron, 75s. per ton; No. 3 G.M.B., 72s. 6d.; No. 4 foundry iron, 71s. 6d.; No. 4 forge, 71s. per ton.

Although at the moment prices for East Coast hematite remain stationary at 75s. 6d. for mixed numbers, there seem to be solid grounds for the belief that a rise is bound to come. Competing keenly for orders, the hematite makers have hitherto been content to sell at current prices, because they have been enjoying the benefit of old contracts for ore and coke at prices very much below those now ruling. On the North-West Coast Bessemer mixed numbers are still quoted at 75s. per ton at works.

LANCASHIRE.—Notwithstanding holiday interruptions, local markets for foundry pig-iron report fairly active conditions, and the leading suppliers are not unduly alarmed so far as new business is concerned. They are not disposed to look for any marked improvement until August is out, but they anticipate increased activity next month from replacement contracts. Prices also may be regarded as steady, current quotations ruling as follow:—Derbyshire No. 3, 74s. 6d.; Staffordshire No. 3, 75s. 6d.; and Scottish brands, from 91s. to 93s. 6d.; all per ton delivered equal Manchester.

THE MIDLANDS.—In the local markets for foundry pig-iron little new business is developing, and the position is likely to be slow for some time, most of the big consumers being covered by contracts for the next month or two. Prices are without change and any immediate alteration is improbable. Quotations rule:—Northants No. 3, 72s. 6d.; Derbyshire No. 3, 76s.; and North Staffs No. 3, 77s., delivered local stations. The demand this month has been poor so far, but this is always a quiet period.

SCOTLAND.—Markets for pig-iron continue dull, and demand generally is on a moderate scale, with the exception of a recent inquiry from the light-castings foundries for a substantial tonnage for forward delivery. Prices continue steady, No. 3 foundry Scotch being quoted at 76s., f.o.t. furnaces.

Finished Iron.

Most of the Black Country mills are now working, and in certain directions there is reported to be some improvement in the demand for crown bars. This iron is quoted locally at £10 to £10 5s. for good makes, but other grades are available at any price from £9 15s. Staffordshire marked bars continue in very fair request, and the mills making this class of iron are well occupied. There is no improvement to be observed in connection with bolt and nut iron. The bulk of the business now being placed is going to the Continent, solely on account of the low prices quoted from that source. Business has been done recently at £6 15s., delivered works in this district, and it is hopeless for the local makers to try to compete with this price. The lowest Staffordshire quotation would be about £9 5s.

Steel.

At Sheffield this week new business in the steel market is reported quiet, but some further improvement is noted in wire rods, but competition in these is keen. Prices are:—Basic billets, soft, £7; semi-hard, £7 12s. 6d.; medium, £8 2s. 6d.; hard, £9 2s. 6d. to £9 12s. 6d.; Siemens acid billets, £9 10s.; wire rods, soft basic, £8 10s.; medium hard, £9 10s. to £10; hard, £10 15s.; acid, £12 5s. to £12 10s.; steel hoops, £9 10s. to £9 15s. The demand for finished steel continues irregular and new buying is distinctly quiet. In the tinplate market most makers are inclined to stand firm, and quotations may be called:—Coke quality, 18s. 3d. to 18s. 6d. basis for approved specifications, net cash, f.o.b. Welsh ports.

Scrap.

With deliveries mostly reduced in volume during the current month, markets for foundry scrap materials are passing through a rather quiet time. On Tees-side, however, there is, if anything, a slightly firmer market for heavy cast iron, and buyers having been paying 66s. 6d. for ordinary quality, although the quotation for good machinery quality is unaltered at 68s. 6d. per ton. In the Midlands there is a fairly good demand for heavy cast-iron scrap in handy sizes at 70s., and 60s. is offered for light cast-iron scrap. In Scotland the cast-iron scrap market is still depressed, and there are few buyers, particularly steelworks, even at the low figures indicated by sellers. Quotations rule about as follow:—Machinery cast-iron scrap, 70s.; old cast-iron railway chairs, 67s. 6d. to 68s.; light cast iron, 60s.

Metals.

Copper.—Markets for warrant copper of late have been to some extent affected by the seasonal decrease of consumptive demand, but, on the whole, quotations indicate a fairly steady tendency, fluctuations as a rule being almost fractional in extent, both for cash and forward dealings. In the American copper statistics for July the only satisfactory feature is the recovery in deliveries to near the high level of 99,000 short tons established in April. Exports have slumped again to 40,000 tons, as compared with a monthly average of 54,700 tons for the first half of this year.

Closing quotations are:—

Cash.—Thursday, £73 10s. to £73 12s. 6d.; Friday, £73 15s. to £73 17s. 6d.; Monday, £74 2s. 6d. to £74 3s. 9d.; Tuesday, £74 to £74 2s. 6d.; Wednesday, £73 15s. to £73 17s. 6d.

Three Months.—Thursday, £74 7s. 6d. to £74 10s.; Friday, £74 12s. 6d. to £74 15s.; Monday, £74 15s. to £74 16s. 3d.; Tuesday, £74 13s. 9d. to £74 15s.; Wednesday, £74 10s. to £74 12s. 6d.

Tin.—Although showing a slight decline in values at last week's close, standard cash tin continues at steady levels, due in measure to a slight slackness of demand usually experienced at this period of the year. Consumption, however, still remains at a high level, and has exceeded that of the same period of 1928, while in some quarters it is even believed that this year's production may create a new record.

Official closing prices:—

Cash.—Thursday, £208 10s. to £208 12s. 6d.; Friday, £209 to £209 5s.; Monday, £210 10s. to £210 12s. 6d.; Tuesday, £209 17s. 6d. to £210; Wednesday, £208 7s. 6d. to £208 10s.

Three Months. — Thursday, £212 10s. to £212 12s. 6d.; Friday, £213 2s. 6d. to £213 5s.; Monday, £214 7s. 6d. to £214 10s.; Tuesday, £213 15s. to £213 17s. 6d.; Wednesday, £212 5s. to £212 7s. 6d.

Spelter.—So far there has been no improvement in the spelter market, although the additional restriction of the European output was to have come into operation at the beginning of this month. Buyers generally show very little interest, and a certain amount of liquidation has been reflected in declining values.

Daily quotations are:—

Ordinary. — Thursday, £24 15s.; Friday, £24 16s. 3d.; Monday, £25 1s. 3d.; Tuesday, £25 1s. 3d.; Wednesday, £24 18s. 9d.

Lead.—Buying on the part of consumers of soft foreign pig has been on a fair scale during the past week, and when the quiet period of the year is considered the consumption is satisfactory.

Prices have been:—

Soft Foreign Prompt.—Thursday, £23; Friday, £22 17s. 6d.; Monday, £22 15s.; Tuesday, £22 17s. 6d.; Wednesday, £23.

Students' Corner.

Q.—How are the various grades of iron made and distinguished?

A.—The grading on the pig bed is usually in numbers:—1, 2, 3, 4, 5 (6, mottled), and white. These numbers vary in hardness, composition and fracture. The No. 1 of any brand of pig-iron is very soft and open-grained. A No. 4 is close-grained and fairly hard. A No. 6, which is mottled, is very hard. A white iron is unmachinable and very brittle. As a rule (but there are many exceptions), there is a close relation between composition, grade number, and fracture, but to observe this, discernment comes by experience.

Q.—What takes place in the blast furnace during melting?

A.—Iron ore is an oxide of iron, and in the blast furnace oxygen is removed and the remaining iron is melted.

At the lower end of the furnace, hot air is blown in, which burns the fuel near the point where it enters, producing carbonic acid (CO_2), which, ascending, through the hot fuel higher up, becomes carbon monoxide (CO) by taking extra carbon from the fuel. This carbon monoxide takes the oxygen from the ore, thus again becoming carbonic acid (CO_2).

After the ore is relieved of its oxygen it is iron in the form of a sponge, exposing a very large surface to the action of the gases. As it passes downwards through the portion where the gas is carbon monoxide and carbonic acid, the spongy iron absorbs carbon from the gas. The amount which will be absorbed is proportional to the speed at which the ore descends. The sponge does not absorb carbon by being in contact with the fuel, but by contact with the gas produced by the combustion of the fuel.

Q.—How are the materials charged into the furnace?

A.—The materials which enter a blast furnace are iron-ore or ironstone; coke and limestone, these enter the furnace at the top. Unless it is a mechanically charged furnace, the materials are taken up on a lift in iron barrows to the charging gallery and tipped into the hopper. When the prescribed amount has been loaded into the hopper, the bell descends a certain distance down by means of a lever and balance weight, the charge then slides off the bell and distributes itself in the furnace. This is repeated night and day as long as the furnace is in blast.

At the bottom end of the furnace the blast enters through water-cooled tuyeres, which usually number at least 6, and the pressure of the blast may be 7 to 14 lbs., according to the age of the furnace plant.

Q.—What is the composition of pig-iron?

A.—As composition of cast iron will be dealt with elsewhere, there remains to be stated in the normal cooling of pig-iron on the bed, that in any brand of iron the relation of composition to grade number and grade fracture should be indicative. Generally speaking, the composition of pig-iron is controlled by the ore used and the working of the furnace. One could not expect pig-iron made from Cleveland ironstone to be similar in composition to pig-iron made from hematite kidney ore. One contains a high percentage of phosphorus, and the other a low percentage of phosphorus. The difference is attributed to a large extent to the percentage of that constituent present in the ores. Also when a furnace is working with hot blast it will invariably produce pig-iron with a higher percentage of carbon and silicon than a furnace working with cold blast.

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¶ We are specialists.

¶ We are by far the largest makers of moulding boxes.

¶ We have a technical staff capable of dealing with your difficulties.

¶ We have some thirty different standard designs of boxes from which to choose.

¶ We have the requisite up-to-date plant and equipment for manufacturing moulding boxes on the most economical lines.

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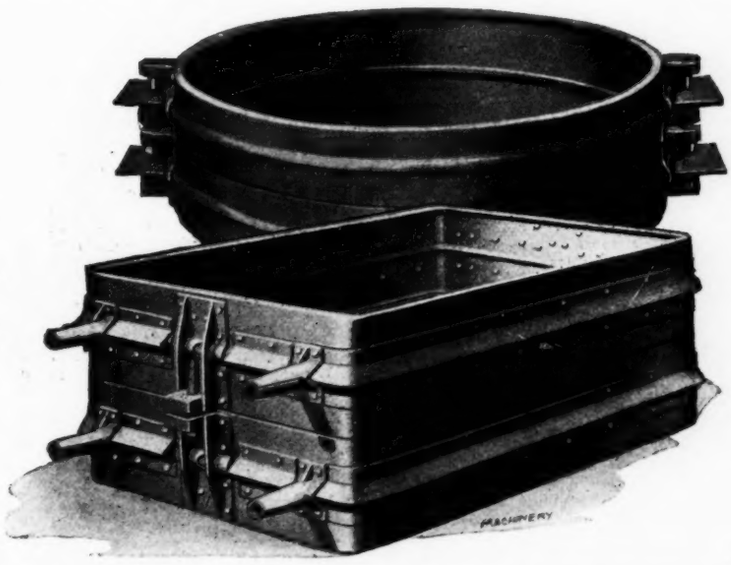
IF STERLING BOXES CANNOT HELP YOU WE WILL TELL YOU SO



STERLING FOUNDRY SPECIALTIES LTD.

London Office :
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BEDFORD

Telephone: 3345 BEDFORD.
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Code: WESTERN UNION.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	73	15	0
Three months	74	10	0
Electrolytic	84	5	0
Tough	77	5	0
Best selected	77	15	0
Sheets	110	0	0
India	94	5	0
Wire bars	84	12	6
Do. Aug.	84	12	6
Do. Sept.	84	12	6
Ingot bars	84	12	6
H.C. wire rods	86	15	0
Off. av. cash, July	72	3	11 13/16
Do. 3 mths., July	72	15	3 5/16
Do., Sttlmnt., July	72	3	8 5/16
Do., Electro, July	84	5	9 1/16
Do., B.S., July	75	11	4 1/16
Aver. spot price, copper, July	72	3	11 13/16
Do. wire bars, July	84	10	9 5/16
Solid drawn tubes			15d.
Brazed tubes			15d.
Wire			11½d.

BRASS.

Solid drawn tubes	12½d.
Brazed tubes	14½d.
Rods, drawn	12½d.
Rods, extd. or rlld.	8d.
Sheets to 10 w.g.	11⅜d.
Wire	11½d.
Rolled metal	10¼d.
Yellow metal rods	8d.
Do. 4 × 4 Squares	8½d.
Do. 4 × 3 Sheets	9d.

TIN.

	£	s.	d.
Standard cash	208	7	6
Three months	212	5	0
English	209	0	0
Bars	212	0	0
Straits	213	12	6
Australian	212	2	6
Eastern	218	10	0
Banca	Nominal		
Off. av. cash, July	209	11	6 3/16
Do., 3 mths., July	213	0	1 3/16
Do., Sttlmt., July	209	11	6 3/16
Aver. spot, July	209	11	6 3/16

SPELTER.

	£	s.	d.
Ordinary	24	18	9
Remelted	22	10	0
Hard	20	15	0
Electro 99.9	27	0	0
English	25	0	0
India	21	10	0
Zinc dust	(Nom.) 34	10	0
Zinc ashes	8	15	0
Off. aver., July	25	7	6 11/16
Aver., spot, July	25	6	7 3/16

LEAD.

	£	s.	d.
Soft foreign ppt.	23	0	0
English	24	5	0
Off. average, July	22	16	10 1/16
Average spot, July	22	16	2 3/16

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	34	10	0
Do. V.M. ex-whf.	32	12	6
Rods	40	0	0
Boiler plates	30	10	0
Battery plates	31	0	0

ANTIMONY.

Special brands, Eng.	50 5 0
Chinese	32 5 0
Crude	Nominal

QUICKSILVER.

	£	s.	d.
Quicksilver	22	0	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

	£	s.	d.
Ferro-silicon—			
25%	7	15	0
45/50%	12	0	0
75%	19	10	0
Ferro-vanadium—			
35/50%	12/10 lb. Va.		
Ferro-molybdenum—			
70/75% c. free	4/- lb. Mo.		
Ferro-titanium—			
23/25% carbonless	11d. lb.		
Ferro-phosphorus, 20/25%	£16	0	0
Ferro-tungsten—			
80/85%, c. fr.	3/3½ lb.		
Tungsten metal powder—			
98/99%	3/6½ lb.		
Ferro-chrome—			
2/4% car.	£32	10	0
4/6% car.	£23	7	0
6/8% car.	£22	10	0
8/10% car.	£22	0	0
Ferro-chrome—			
Max. 2% car.	£33	0	0
Max. 1% car.	£38	0	0
Max. 0·70% car.	£40	0	0
70%, carbonless	1/2 lb.		
Nickel—99% cubes, or pellets	£175	0	0
Ferro-cobalt	9/4 lb.		
Aluminium 98/99%	£95	0	0
Metallic chromium—			
96/98%	2/6 lb.		
Ferro-manganese (net)—			
76/80% loose	£13	15	0
76/80% packed	£14	15	0
76/80%, export	£14	0	0
Metallic manganese—			
94/96%, carbonless	1/6 lb.		

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£0 2 0
Finshed bars, 18% tungsten	£0 2 9

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 7/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.
Bars cut to length, 10% extra	

SCRAP.

	£	s.	d.		£	s.	d.
South Wales—							
Heavy steel					3	15	6
Bundled steel and shrngs.	3	12	0	to 3	15	0	
Mixed iron and steel	3	10	0	to 3	11	6	
Heavy cast iron	2	18	0	to 3	0	0	
Good machinery for foundries					3	5	0
Cleveland—							
Heavy steel					3	5	0
Steel turnings					2	17	6
Cast iron borings					2	16	0
Heavy forge					3	17	6
W.I. piling scrap					3	11	6
Cast-iron scrap	3	6	6	to 3	8	6	
Lancashire—							
Cast-iron scrap	3	0	0	to 3	10	0	
Hvy. wrought					3	17	6
Steel turnings					2	17	6
Scotland—							
Heavy steel					3	17	6
Cast-iron borings					2	14	6
Wrought-iron piling					3	15	0
Heavy machinery					3	8	6

London—Merchants' buying prices delivered yard.

	£	s.	d.
Copper (clean)	64	0	0
Brass	42	0	0
Lead (less usual draft)	20	10	0
Tea lead	18	10	0
Zinc	16	0	0
New aluminium cuttings	68	0	0
Braziery copper	56	0	0
Gunmetal	57	0	0
Hollow pewter	155	0	0
Shaped black pewter	110	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	75/-
Foundry No. 3	72/6
Foundry No. 4	71/6
Forge No. 4	71/-
Hematite No. 1	76/-
Hematite M/Nos.	75/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	86/-
,, d/d Birm.	92/-
Midlands—	
Staffs. common*	—
,, No. 4 forge*	73/-
,, No. 3 fdry*	77/-
Shrops. basic	—
,, Cold blast, ord.	—
,, ,, roll iron	—
Northants forge*	68/6
,, fdry. No. 3*	72/6
Derbyshire forge*	72/-
,, fdry. No. 3*	76/-
,, basic*	—

* d/d Black Country dist.

Scotland—	
Foundry No. 1	79/-
,, No. 3	76/-
Hem. M/Nos.	80/-
Sheffield (d/d district)—	
Derby forge	67/-
,, fdry. No. 3	71/-
Lincs. forge	—
,, fdry. No. 3	74/6
E.C. hematite	86/-
W.C. hematite	87/-
Lincs. (at furnaces)—	
Forge No. 4	—
Foundry No. 3	—
Basic	—
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, fdry. No. 3	74/6
Northants foundry No. 3	—
Dalzell, No 3 (special)	102/6 to 105/-
Summerlee, No. 3	93/6
Glengarnock, No. 3	—
Gartsherrie, No. 3	93/6
Monkland, No. 3	93/6
Shotts, No. 3	93/6

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

	£	s.	d.		£	s.	d.
Iron—							
Bars (cr.) nom.					10	15	0
Nut and bolt iron	9	0	0	to 9	10	0	
Hoops	11	0	0	to 11	10	0	
Marked bars (Staffs) f.o.t.					12	0	0
Gas strip	11	0	0	to 11	10	0	
Bolts and nuts, ¾ in. × 4 in.					15	5	0
Steel—							
Ship plates	8	12	6	to 8	17	6	
Boiler plts.	9	15	0	to 10	10	0	
Chequer plts.					10	12	6
Angles					8	2	6
Tees					9	2	6
Joists					8	2	6
Rounds and squares, 3 in. to 5½ in.					9	2	6
Rounds under 3 in. to ⅜ in. (Untested)					8	0	0
					and upwards		
Flats, over 5 in. wide and up					8	7	6
Flats, 5 in. to 1½ in.					7	17	6
Rails, heavy					8	10	0
Fishplates					12	10	0
Hoops (Staffs)	10	0	0	to 10	10	0	
Black sheets, 24g.	10	5	0	to 10	10	0	
Galv.cor.shts., 24g.	13	5	0	to 13	10	0	
Galv. fencing wire 8g. plain					12	0	0
Billets, soft	6	7	6	to 6	15	0	
Billets, hard	7	10	0	to 8	0	0	
Sheet bars					6	5	0
Tin bars					6	5	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1/4
Sheet to 10 w.g.	1/5
Wire	1/6½
Rods	1/5
Tubes	1/9¼
Castings	1/4

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	10d. to 1/4
Rolled—	
To 9 in. wide	1/4 to 1/10
To 12 in. wide	1/4½ to 1/10½
To 15 in. wide	1/4½ to 1/10½
To 18 in. wide	1/5 to 1/11
To 21 in. wide	1/5½ to 1/11½
To 25 in. wide	1/6 to 2/-
Ingots for spoons and forks	10d. to 1/6½
Ingots rolled to spoon size	1/1 to 1/9½
Wire round—	
3/0 to 10 G.	1/7½ to 2/2½

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	21.26
No. 2 foundry, Valley	18.50
No. 2 foundry, Birm.	14.50
Basic	20.26
Bessemer	20.76
Malleable	20.76
Grey forge	19.76
Ferro-mang. 80% d/d	105.00
O.-h. rails, h'y at mill	43.00
Bessemer billets	35.00
O.-h. billets	35.00
O.-h. sheet bars	35.00
Wire rods	42.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.95
Tank plates	1.95
Beams, etc.	1.90
Skelp, grooved steel	1.90
Skelp, sheared steel	1.90
Steel hoops	2.20
Sheets, black, No. 24	2.85
Sheets, galv., No. 24	3.50
Sheets, blue an'l'd, No. 13	2.35
Wire nails	2.55
Plain wire	2.50
Barbed wire, galv.	3.20
Tinplates, 100 lb. box	$5.35

COKE (at ovens).

Welsh foundry	24/- to 27/6
,, furnace	21/- to 24/-
Durham and North. foundry	20/- to 21/6
,, furnace	19/6
Midlands, foundry	—
,, furnace	20/- and up

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes	20×14 box	18/3
,,	28×20 ,,	36/6
,,	20×10 ,,	26/3
,,	18¾×14 ,,	18/9
C.W.	20×14 ,,	15/3
,,	28×20 ,,	33/6
,,	20×10 ,,	21/3
,,	18¾×14 ,,	16/-
Terneplates	28×20	33/6 per box basis f.o.b.

SWEDISH CHARCOAL IRON & STEEL.

Pig-iron	£6	0	0	to £7	10	0
Bars, hammered, basis	£17	10	0	to £18	10	0
Bars and nail-rods, rolled, basis	£15	15	0	to £16	15	0
Blooms	£10	0	0	to £12	0	0
Keg steel	£32	0	0	to £33	0	0
Faggot steel	£20	0	0	to £24	0	0
Bars and rods, dead soft, steel	£10	0	0	to £14	0	0

All per English ton, f.o.b. Gothenburg.

TUBES AND FITTINGS.

Over ½ in. up to 6 in.

	Tubes.	*Fittings.*
Gas	65%	47½%
Water	61½%	42½%
Steam	57½%	37½%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.	
Aug.	15 ..	73	10	0	dec. 16/3
„	16 ..	73	15	0	inc. 5/-
„	19 ..	74	2	6	„ 7/6
„	20 ..	74	0	0	dec. 2/6
„	21 ..	73	15	0	„ 5/-

Electrolytic Copper.

		£	s.	d.		
Aug.	15 ..	84	5	0	No	change
„	16 ..	84	5	0	„	„
„	19 ..	84	5	0	„	„
„	20 ..	84	5	0	„	„
„	21 ..	84	5	0	„	„

Standard Tin (cash).

		£	s.	d.		
Aug.	15 ..	208	10	0	inc.	5/-
„	16 ..	209	0	0	„	10/-
„	19 ..	210	10	0	„	30/-
„	20 ..	209	17	6	dec.	12/6
„	21 ..	208	7	6	„	30/-

Tin (English ingots).

		£	s.	d.		
Aug.	15 ..	208	10	0	No	change
„	16 ..	209	0	0	inc.	10/-
„	19 ..	210	10	0	„	30/-
„	20 ..	210	0	0	dec.	10/-
„	21 ..	209	0	0	„	20/-

Zinc Sheets (English).

		£	s.	d.		
Aug.	15 ..	34	10	0	No	change
„	16 ..	34	10	0	„	„
„	19 ..	34	10	0	„	„
„	20 ..	34	10	0	„	„
„	21 ..	34	10	0	„	„

Spelter (ordinary).

		£	s.	d.		
Aug.	15 ..	24	15	0	dec.	1/3
„	16 ..	24	16	3	inc.	1/3
„	19 ..	25	1	3	„	5/-
„	20 ..	25	1	3	No	change
„	21 ..	24	18	9	dec.	2/6

Lead (English).

		£	s.	d.		
Aug.	15 ..	24	10	0	No	change
„	16 ..	24	5	0	dec.	5/-
„	19 ..	24	5	0	No	change
„	20 ..	24	5	0	„	„
„	21 ..	24	5	0	„	„

Exports of Iron Castings in July and the seven months 1929, compared with July and the seven months 1928.

	July, 1928.	July, 1929.	Seven months, 1928.	Seven months, 1929.	July, 1928.	July, 1929.	Seven months, 1928.	Seven months, 1929.
BUILDERS' CASTINGS—	Tons.	Tons.	Tons.	Tons.	£	£	£	£
Stoves, Grates, etc., Cisterns, Baths, etc., and cooking and washing boilers—								
To Argentine Republic	179	154	1,048	1,265	7,551	4,956	44,885	58,090
„ British South Africa	232	268	2,137	2,115	8,229	9,892	74,464	75,446
„ „ India	82	157	903	1,011	3,135	5,547	39,649	38,815
„ Australia	48	87	407	442	3,324	3,470	28,819	25,427
„ New Zealand	159	107	1,161	817	8,963	6,086	58,321	52,580
„ Other countries	836	963	5,478	5,920	37,344	45,872	253,912	270,534
Total	1,536	1,736	11,134	11,570	68,546	75,823	500,050	520,892
PIPES AND FITTINGS—CAST—								
To Argentine Republic	1,104	2,205	5,482	15,897	9,481	18,808	56,194	150,850
„ British South Africa	319	356	2,927	4,223	4,821	5,917	46,881	55,190
„ „ India	541	366	5,457	2,800	7,841	7,497	69,331	37,997
„ Straits Settlements and Malay States	1,751	3,317	9,394	14,758	15,650	23,346	83,965	107,280
„ Ceylon	113	55	767	1,232	1,545	856	9,373	12,839
„ Australia	166	117	6,079	2,751	2,285	2,189	66,285	29,531
„ Other countries	3,547	5,185	33,979	34,772	47,509	67,262	446,709	428,081
Total	7,541	11,601	64,085	76,433	89,132	125,875	778,738	821,768
HOLLOW-WARE—								
Cast, not Enamelled, and Cast, Tinned	389	379	2,708	2,711	14,531	14,484	101,613	98,462
„ Enamelled	60	105	460	528	7,059	10,062	42,694	47,264
CASTINGS, in the rough—								
Iron	20	86	104	141	882	3,283	5,502	5,401
Steel	26	112	492	469	1,457	4,613	18,813	18,109

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